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THE RECOVERY AND RESTORATION OF METROPOLITAN WATER WORKS FOLLOWING NUCLEAR WAR ATTACK

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AN ASSESSMENT OF THE STATUS OF PREPAREDNESS OF METROPOLITAN WATER WORKS WITH RESPECT TO CIVIL DEFENSE AND A STUDY OF METHODS AND PROCEDURES TO RECOVER DAMAGED SYSTEMS IN EARLY POST ATTACK PERIOD

A REPORT PREPARED FOR THE OFFICE OF CIVIL DEFENSE, DEPARTMENT OF DEFENSE UNDER THE PROVISIONS OF CONTRACT NO. OCD-OS-62-106

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THE RECOVERY AND RESTORATION OF METROPOLITAN WATER WORKS FOLLOWING NUCLEAR WAR ATTACK

An assessment of the Status of Preparedness of Metropolitan Water Works with respect to Civil Defense and a Study of Methods and Prodedures to Recover Damaged Systems in Early Post Attack Period

Prepared for

The Office of Civil Defense, Department of Defense

Under the Provisions of
Contract No. OCD-OS-62-106

"The report has been reviewed in the Office of Civil Defense and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Office of Civil Defense".

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CHAPTER I

WATER SUPPLY DURING CIVIL DEFENSE EMERGENCY

FOREWORD

Statement of Problem

Availability of water, so critically essential for human survival, is of utmost importance to every individual at the time of disaster. People living in the population centers of metropolitan areas are accustomed to obtaining their daily water requirements from community water supplies as the need arises. The reliability of the water service is taken for granted. The waterworks systems serving such areas have fulfilled well the basic objective of supplying a quality water in adequate quantity for such needs at all times.

Waterworks personnel know that water systems are vulnerable to damage and that interruptions for relatively short intervals of time do occur. This has been demonstrated during natural disaster and civil emergencies. Through advance preparation for emergency operation and water distribution by improvised methods, essential needs have been met during such emergencies.

The structural damage and nature of contamination that could result from modern warfare have not been experienced in the United States. Systems may be severely damaged and the ability to meet the water needs during such an emergency; to salvage what may be left; to provide the much-needed water by emergency methods or from auxiliary supplies; to provide a means for decontamination and fire suppression; and to re-establish the supply system has not been confirmed.

Waterworks need procedures and methods for the recovery and restoration of the community water system so that a war-created disaster, as well as a natural disaster, will have a minimal effect on the continuous operation of the system.

A major problem in waterworks Civil Defense is the development of realistic methods by which emergency repairs can be made to restore and/or maintain the essential components of the community system, so as to provide minimum quantities of water for firefighting, domestic and other critical needs. To meet the needs imposed by the type of disaster which is currently possible requires an understanding of the destructive forces which science has developed for war purposes. From the research which has accompanied this development, some information is available on the destruction of structures and facilities. Assumptions applicable to waterworks systems and their operation can be made. Waterworks management using this information can develop procedures for recovery and operation.

To effectively carry out these procedures to sustain a continuing supply of water in a post attack period requires greater preparation in advance than has been necessary for natural disaster and civil emergencies. The capability to recover will depend upon the availability of knowledgeable men, sufficient equipment and material, and means of communication. These components, so essential for recovery, will suffer damage in a nuclear war attack. The success with which these components survive the attack will influence greatly the rate of and ability to recover. While not a part of this study, that portion of the advance preparation that provides for "hardening" of facilities to reduce destruction is also important as it influences directly the character and extent of damage, and thus the system and facilities which waterworks personnel will have to work with in the post-attack period.

A nuclear attack on any country will show that the areas affected by the explosion of the weapon (blast and shock, initial radiations, thermal radiations, and residual radiation from fallout) can be separated into three classes of areas. The classes of areas will depend upon the intensity of each of the destructive phenomena and on the way in which they interact with the environment.

Study Objectives

The objectives of this study are (1) to review and assess the existing status of waterworks preparedness with respect to civil defense, (2) to study methods of improvisation and repair of damaged plants, (3) to develop preliminary operational methods for emergency water supplies, (4) to develop training methods and materials for use by auxiliary repair and maintenance personnel.

Scope of Study

A detailed review has been made of existing waterworks preparedness with respect to civil defense in nine large metropolitan areas. The response of the pumping, treatment, storage and distribution facilities to the destructive forces of natural and war created disaster were considered. The management planning for operation and recovery in a period of civil defense disasters; the availability of knowledgeable personnel; the development of mutual aid arrangements; the stockpiling of equipment, material, and emergency supplies; the development of alternate sources of supply and alternate methods of water treatment and distribution were all considered.

This study was directed by OCD to a consideration of the effects of nuclear weapons on waterworks systems and applicable recovery methods and operations. It does not include consideration of the effects of biological or chemical warfare.

The emergency water needs in a post attack period were studied. Procedures for the development of inventories of auxiliary supplies showing the

possible sources of supply together with methods of distribution were studied.

The many activities and measures that will lessen the effect of the forces of destruction and increase the capability for recovery that have been considered in this study are presented as an aid in the training of personnel and the development of a state of readiness.

Methods of Study

This study is directed to a consideration of the effects of nuclear weapons and radioactive fallout on waterworks facilities and operations; the response to these forces and the countermeasures to provide the capability for recovery.

Consideration has been given to the effect forces of disaster may have on each of the units of a metropolitan water supply system and the response of the unit to such a condition. Applicable measures of repair and/or decontamination of such units were studied. The effect of an interruption in the supply of water from the source facility, or change in quality rendering it unusable, was considered as well as the effect a decrease in waterworks operating personnel might have on the over-all operation. The scaling of the forces of disaster included both minimum conditions likely to result in a significant effect on the system, and a maximum condition just short of complete destruction of the entire system. Procedures for use of alternate facilities have been considered for the event that portions of a system experience damage to an extent precluding repair under emergency conditions.

The water utility disaster operations considered herein have been grouped into the following time sequence of events:

Preparatory Phase (advance preparation)
Tension Phase (alert - "buttoning-up")
Attack and Shelter Phase (personnel protection)
Survival Phase (emergency operations)
Recovery Phase (emergency restoration)
Reconstruction Phase (system reconstruction)

The operational plan is designed to take advantage of any amount of warning time which may be available. Furthermore, the plan provides for coordinated operations simultaneously in more than one phase as indicated by prevailing conditions and priority needs.

To develop methods of improvisation and repair of water supply facilities, it has been necessary to ascertain, and in some cases, assume the importance of the various elements of a waterworks system and the work environment which would exist under various war disaster conditions. Basic information has been obtained from extensive study of the literature concerning past natural disasters

and the reports of the damages inflicted on water systems by the heavy bombing of metropolitan areas in World War II. Studies have been made also of the time, material and man-hour costs of repairing main and fire hydrant breaks in normal operations. From this information a determination of the extent of damage waterworks facilities may experience and an estimation of the time required for repair or replacement have been made. In some instances, this has involved the establishment of a necessity priority rating of the unit in relation to the emergency recovery operation.

The following techniques have been used to evaluate the possible results of nuclear attack:

1) A scaling of vulnerability for each unit in an over-all consideration of system facilities.

2) A "degree of blast damage" scale for each unit- slight, moderate, severe, including "missile" damage.

3) An estimate of the time to accomplish each manual operation and preventive maintenance job necessary in the emergency operation of the waterworks system.

4) An indication of the parts of the facility that might be damaged and the extent of damage, together with a determination as to whether the part should be repaired, replaced, or bypassed.

5) An indication of the procedure to return the unit to operation with alternate procedures, if possible, including a procedure to operate without the unit.

6) An estimate of the working time required to accomplish the indicated procedure. This estimate includes a listing of the part or parts needed, the special equipment needed, and whether withdrawn from inventory or stockpile.

7) An estimate of the length of time the damaged unit might have to be out of operation pending repair or replacement as related to its scaled priority.

8) A scaling of the entry time, time of exposure, and total accumulated radiation dose of personnel for various radiation levels at (H + 1) of 50 to 10,000 r/hr and considering shelters of various protective factors (10, 50, 100, 250, and 1,000).

The presence or absence of external radiation as an environmental hazard to the workmen is considered in the operational methods and in estimating time requirements for recovery and restoration.

A procedural guide is presented for the post attack repair and emergency restoration operations for the time between the alert period and (D + 14). This procedure has been given the form of a sequence of synchronized recovery activities following an assumed attack resulting in light to moderate damage to a water system serving one million people.

Minimum emergency water needs have been determined by establishing a series of use categories with time-phased allowances assigned to each. Based on this information, methods for determining alternate sources of supply and applicable means of distribution such as hauling have been outlined.

The criteria for the assessing the status of preparedness together with the procedures for establishing a state of readiness that have been formulated in the various parts of this project are presented in outline that they might be used in developing an emergency program for a water utility or in training personnel in emergency preparation and operation. Although no two communities are identical in terms of the problems or resources, many of the procedures and activities are, nevertheless, applicable to most large community water supply systems.

ACKNOWLEDGMENTS

Acknowledgment is gratefully made for the cooperation of the U.S. Public Health Service. Members of the headquarters staff in Washington, D.C., and staff members in regional offices have been most helpful in providing much of the reference material referred to in this study, in making suggestions, and in giving information and advice during the study. Special thanks are extended to Dr. Gordon E. McCallum, Asst. Surgeon General, and Mr. Martin Kunkel, Planning Officer, National Water Plan, for their assistance.

To provide assurance that procedures and methods developed in this study would provide information useful to the waterworks industry, administrative personnel of ten metropolitan area systems, have advised by invitation, on the study, (Appendix A).

To obtain information on current preparedness and planning for an extreme emergency, the management of metropolitan systems also cooperated in the preparation and review of the material presented in the chapter on "Assessment of Waterworks Preparedness with Respect to Civil Defense." Appreciation for this assistance is gratefully extended to:

Mr. Paul Weir, General Manager, Water Department, Atlanta, Georgia

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Mr. Robert S. Millar, Secretary Manager, Board of Water Commissioners, Denver, Colorado

Mr. Gerald Remus, General Manager, Board of Water Commissioners Detroit, Michigan

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Mr. Edward J. Clark, Chief Engineer, Department of Water Supply, Gas & Electricity, New York City, New York

Mr. Gerald E. Arnold, General Superintendent, Water Department, Philadelphia, Pennsylvania

Mr. H. O. Hartung, Exec. Vice-President and Manager of Production, St. Louis County Water Co., St. Louis, Missouri

Mr. Harry W. Tracy, Manager, Water Purification Division, Water Department, San Francisco, California

The action of the Conference of State Sanitary Engineers in recognizing the essentiality of water after a disaster and recommending the full cooperation of State Engineers in this study of preparedness is acknowledged. State Engineers and members of their staffs who assisted by supplying information requested in a special questionnaire submitted to them and by personal contacts are named in the Appendix B.

A most heartening occurrence during this study was the action of the Board of Directors of the American Water Works Association naming a Committee on Radioactivity and Civil Defense. Through the farsightedness of the Board of Directors and Mr. Raymond J. Faust, Executive Secretary, a direct avenue of approach to the waterworks industry for dissemination of information, guides, and procedures between the Office of Civil Defense and waterworks management is now established.

CHAPTER II

SUMMARY

ASSESSMENT OF PREPAREDNESS STATUS

I. The assessment of preparedness of the water supply systems in metropolitan communities to recover from a natural disaster, made as part of this study, has indicated a state of preparedness for recovery of 73 percent, based on an arbitrary grading scale. Since the water supply systems experiencing storms at any one time are those in a relatively small portion of the nation - or a relatively few systems in one general area - it is apparent that emergency needs are provided from outside sources which come to the aid of the stricken communities.

The water supply systems of large metropolitan areas are constructed to withstand to a high degree the damaging effects of storms that are known to occur from time to time. Trained waterworks personnel utilizing materials in inventory for the operation and maintenance of the system have repeatedly demonstrated that, with the ample outside aid which may be quickly obtained, essential water is supplied without loss of life or extensive interruption in the industrial activity.

II. The study indicated that the preparedness of metropolitan water supply systems to recover from the effects of a nuclear war-created disaster* is only 50 percent. While it might be possible to effect rapid recovery with prompt and extensive outside aid, it does not appear that such assistance will be forthcoming in the immediate post-attack period. Since an attack would most probably result in simultaneous extensive damage to many metropolitan areas, there would be little hope of effective outside help coming to any given area. The present state of preparedness is not adequate to assure recovery of the water supply systems serving our metropolitan communities without loss of life and serious interruption of industrial activity.

III. The water supply utilities of metropolitan communities can improve their state of preparedness and enhance the capability for early recovery in several ways. These are:

1) Providing protective shelters for waterworks personnel in close proximity to essential facilities of the water supply system.

Study of the measures provided for the protection of waterworks personnel from fallout in metropolitan areas indicated 16 percent protection. Four of nine systems had no protection in this respect and five had only partial protection.

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* Surprise attack inflicting light to moderate damage, with radioactive fallout.

The early fallout radiation from a nuclear weapon will cover an area 10 to 100 times greater than that effected by blast. Injury and death of exposed waterworks personnel can paralyze recovery. Ordinary shelter against rainfall, light, heat, and cold will be ineffective in shielding personnel from the ionizing fallout radiation. Fallout shelters for key personnel located at critical operating facilities are required if early recovery is to be accomplished.

2) Pre-attack vulnerability studies of water supply systems, the development of damage criteria, and the hardening of systems.

For nine metropolitan systems studied, a vulnerability resistance of 48 percent was determined.

Vulnerability studies and damage criteria provide the basis for development of efficient procedures for recovery, determination of required manpower, and selection of the essential material, equipment, and supplies that should be stockpiled.

3) Developing an adequate staff of key personnel knowledgeable and trained in recovery and restoration operations.

The study of nine metropolitan systems indicated a personnel preparedness for early post-attack recovery of 68 percent.

Of prime concern is the capability of the waterworks personnel to assess a condition of disaster promptly, to initiate and carry out effective recovery measures without panic, and to restore service or provide survival water through other improvised means. Rapid recovery following natural disasters has been achieved, but under present conditions the problems posed by a war-created disaster could not be effectively handled. Adequate numbers of key waterworks personnel having equipment for their protection and trained in methods and procedures for recovery operations in the war-created environment are not available in the waterworks industry.

4) Developing an organizational and procedural plan for recovery and post-attack operation.

It was found that the metropolitan areas studied have organizational and procedural plans for disaster recovery operations for 65 percent of the needs.

The plans appear to be adequate for natural disasters, but less than adequate for disasters that may result from nuclear warfare. There is need for greater definition of "who" does "what, where, and when" to implement recovery operations.

Definition of policies, organization, and procedures will facilitate uninterrupted leadership, reduce panic, and bring about the attainment of the

full recovery capability provided through advance preparation.

5) Developing information on alternate sources of supply, and procedures for obtaining and distributing of water during the early post-attack recovery period.

The study showed a preparedness of 54 percent for the supplying of potable water by improvised methods from other than community water supply sources.

Some areas have inventoried alternate sources of supply and considered methods for developing and distributing the water in the early post-attack period for survival needs, but other areas have not. The need for this is found to be greater in those metropolitan areas where the utility supply is taken from one source with a high degree of vulnerability. It is found also that such metropolitan areas generally have fewer alternate sources of supply that can be developed by improvised methods.

6) Providing through mutual aid and joint-venture arrangements for maximum use of surviving water supply facilities, and stockpiling equipment and material to permit recovery of a minimum essential supply.

The study indicated an advance preparedness with respect to mutual aid of 33 percent.

The utilities studied represent the larger water systems in the nation, and it is accordingly understandable that they generally look upon mutual aid arrangements with relatively small utilities as not particularly advantageous. While this may be the situation for many disasters, a threat analysis of modern warfare indicates that the larger systems may experience damage resulting in total loss of water source. Under such a condition, the dispersal afforded by the additional sources of supply that are a party to the mutual aid may reduce the vulnerability of the metropolitan system even though the normal water supply needs of the metropolitan area exceed greatly the combined supply that may be available from the surrounding systems. The advantages that come through joint-venture agreements are even more apparent.

Only a few mobile and portable water treatment units of very limited capacity are available for emergency use. Chemicals that might be needed for increased emergency water treatment such as chlorine and alum are stored in very limited amounts. There is little interest in joint stockpiling of equipment and repair materials with other utilities.

POST ATTACK RECOVERY OPERATIONS

A nuclear attack which damages a water utility will create conditions that may be considered in three distinct operational time phases. These are:

a) Survival phase, in which survivors are in shelters using stored water. Management will have an opportunity to assess the damage and to adjust the Civil Defense post-attack recovery and operational plan to the prevailing post-attack conditions and to initiate emergency operation.

b) Recovery and restoration phase, in which knowledgeable waterworks operators may continue the operation of the surviving system to its maximum capability. At the same time damaged facilities may be restored to produce at least the minimal water need for drinking, cooking, sanitary use, fire fighting, decontamination, and other essential needs.

c) Reconstruction phase, in which efforts are directed to restoring the system to pre-attack operations as needs indicate.

This chapter is directed primarily toward defining operations in the recovery and emergency restoration phase. The main effort must be to have water available when the in-shelter stored water is exhausted and survivors begin to leave the shelters. In this period a survivor may have little choice in the water he must use. He must utilize the safeguards that he himself may apply to render the available water usable.

Advance measures to minimize the disrupting effect of an attack and to enhance the waterworks' capability to meet essential post-attack water needs are the following:

a) Develop and maintain an adequate number of trained employees.

b) Develop a coordinated plan for disaster operation.

c) Formulate operational disaster procedures for post-attack actions that afford flexibility for effective use of surviving facilities and personnel.

d) Develop and maintain a "hardened" water supply system to minimize damage to operating facilities and essential power supply; provide stored water supplies, dispersed in areas of need, which will be adequate for essential needs during period of initial recovery.

e) Provide protected stockpiles of equipment, materials and tools essential for disaster operation and recovery.

f) Arrange for mutual aid and joint venture cooperation with neighboring utilities.

g) Provide for the sheltering of personnel at locations most effective for post-attack operation and recovery.

h) Provide for post-attack communications and radiological monitoring.

i) Plan with other Civil Defense disciplines for the most effective utilization of in-shelter water storage and for the use of water that may be captured in the distribution system.

To facilitate development of post-attack operation and recovery capability the actions considered necessary are presented time phased in an operational guide. The waterworks personnel and equipment considered necessary to accomplish recovery at a rate sufficient to satisfy the water needs are listed. The time at which actions can be initiated and the period to accomplish them is dependent upon many considerations on which decisions will be made in the light of conditions of disaster.

The actions and the time at which they should be started for one assumed set of conditions are:

a) Initial appraisal of attack and effect upon the water system, a command post operation starting immediately after the attack (D-day).

b) Initial assessment of damage to facilities, a probing operation limited by the radiation intensity and the allowable exposure time. This action will commence on (D + 1), while most personnel are sheltered and radiological units are determining levels of radiation.

c) Development of preliminary operational plans, revised as assessment information improves. Trans-attack efforts to conserve stored water may be continued if personnel are sheltered close enough to facilities to do so without undue exposure during the operation. (D + 2).

d) Detailed assessment of damage and evaluation of the system started. Personnel can now be exposed long enough to permit work of activating stand-by sources of water (which may be sources of poor quality for fire fighting) and to control water loss from damaged distribution system, reservoirs, and transmission lines. (D + 4).

e) Initiate recovery of sources, treatment, and transmission facilities; reactivate use of stored quality water; initiate quality water

service to critical and high-priority users, such as hospitals and mass-care centers; initiate rationed service to survivors by improvised methods. (D + 7). This may have to be poor quality water with potable water supplied by alternate improvised methods.

f) Complete detailed plans for restoration and continue recovery operations to supply from 10 to 40 gallons per day per survivor through the distribution system. (D + 14).

Data and methods exist for estimating the effort, effectiveness, and the time-scale of conducting radiological recovery operations. Utilizing this information, knowledgeable waterworks men can initiate organized recovery operations as early as three to five days after the blast in areas where the H plus 1 hr intensity is between 1000 and 5000 r/hr.

A method for the estimation of the radioactivity in surface water supplies that have received radioactive fallout, based on measurement of the radiation from such fallout on land surfaces adjacent to the exposed water, is given in Figures 5, 6, and 7. An alternate method given is based on measurement of the increase in turbidity due to the fallout particulate matter.

The major nuclear weapons effects (initial nuclear radiation, thermal radiation, radioactive fallout, and blast and shock damage) together with countermeasures that may be used in waterworks operations are given. Those measures taken in advance of attack will control to a great extent the degree of recovery and post-attack operation that can be accomplished. Through post-attack operations the most effective use of surviving facilities can be made; however, without appropriate advance preparation the rate of recovery and restoration of the water system may not be adequate to supply essential water needs even with the help of improvised methods.

IMPROVISED METHODS AND PROCEDURES FOR SUPPLYING EMERGENCY WATER

To provide for essential water needs in all areas experiencing nuclear attack it may be necessary to supplement the surviving waterworks facilities to a considerable extent through improvised methods. One of the most important advance considerations is the determination of emergency water sources from which minimum supplies can be delivered to survivors. When the water supply stored in shelters is exhausted, people will expect Civil Defense and the water utility to have a supply available. Water will have to be delivered to locations from which survivors can obtain it without exposure to excessive residual radioactivity.

The use of inventories of emergency sources prepared in advance together with post-attack damage assessment will provide information helpful in the determination of surviving supplies and means of making them

available in areas of need. Inventories should include the location of all surface and ground water supplies in the area, the quantity available and the quality, treatment, pumping, equipment, material, and personnel needed to utilize them.

Typical water allowances time-scaled to assist in determining the emergency water requirements are given in Tables XX and XXI. The various uses made of the supply, such as potable, sanitary, fire fighting, industrial, or agricultural, and the quality and quantity requirements for each use should be established in the pre-attack period. A priority scale should also be established. The minimum quality and quantity requirements under emergency conditions will be significantly different from those under normal conditions. Maps showing the location of high-priority users with respect to the plotted location of emergency sources and locations where water distribution points may be established will aid in determining post-attack requirements and methods.

In planning the distribution of emergency water, consideration can be given to use of undamaged portions of the distribution system by rerouting and isolation, the use of normal or emergency sources of supply, the use of emergency mobile treatment equipment, and delivery of water by hauling.

The public will need information concerning the availability, location, and condition of emergency water supplies throughout the survival and recovery phases. Procedures for keeping the public informed on prevailing conditions are suggested.

GUIDE TO ADVANCE PREPARATION FOR RECOVERY OF WATER SUPPLY

There is presented, in outline, suggested procedures to be used by waterworks management in the preparation of a comprehensive plan for recovery following a nuclear disaster.

As a first step in the preparation for recovery, the metropolitan area water utility should appoint a full-time disaster coordinator. He should guide the utility in making necessary studies and developing a preparedness program. Provisions for the development of a disaster organization, making use of all regular and auxiliary personnel, are presented. The regular waterworks personnel provide the most reliable source of manpower for continuity of operations. Auxiliary personnel to back up the regular personnel may be highly trained or specialized workers from closely related fields or they may be from other utilities provided possibly through mutual aid or joint venture agreements. Qualified auxiliary personnel may also come from supervisory and regulatory agencies as well as from personnel of industrial plants manufacturing waterworks equipment.

Measures for the preparation of procedures essential in the pre-attack, trans-attack, and post-attack operations are outlined. In the pre-attack

period the initiation of an effective advance preparation program is of prime importance. During the trans-attack period attention must be given to the sheltering of personnel and to the conservation of water through isolation of stored supplies and sectionalization of the distribution system. Post-attack operations are concerned with using the workmen most effectively to recover the water system, supply emergency water, and make conservative use of the water that has remained uncontaminated after the attack.

Procedures for assuring recovery capabilities through mutual aid, reliable communication, system security, sheltering of personnel, facility hardening, and stockpiling of essential equipment and materials are indicated.

Methods for the supplying of essential water to those survivors that cannot be supplied from the piped community system during the early post-attack period are listed.

The effectiveness with which these many considerations have been utilized to develop a satisfactory preparedness status can be evaluated by answering such questions as:

1) What are the actions available?

2) How effective is each action?

3) What equipment and skills are required to execute the action?

4) Does the plan provide for these post-attack?

5) What kind of organization and plan is needed to carry out the action? Is this provided?

6) What training and education is needed to meet the needs of the plan? Does the utility program provide for this?

CHAPTER III

ASSESSMENT OF WATER WORKS PREPAREDNESS WITH RESPECT TO CIVIL DEFENSE

The fact that water is a necessity of life has imposed upon water purveyors the requirement of reliability. The complexity of water supply systems has grown together with the served population, and ever greater efforts have been required to maintain or improve their dependability. Material and equipment are maintained in such quantity that the effect of any normal emergency can be overcome with a minimum of time and inconvenience. Operational procedures are well established and personnel are trained to handle most emergencies whenever they occur. Many water utilities have a record of operating for 100 years or more with no total shut-down.

In localities where hurricanes, tornadoes, earthquakes, floods, or fires have been experienced, waterworks design practice includes measures for minimizing the damaging effect of these phenomena. Appropriate methods have also been developed for system repair. However, in areas where destructive forces have not been experienced at least occasionally the need for disaster planning is not well recognized. During World War II a program of planning and training for operation of water supplies during a war-created emergency was initiated by the Office of Civil Defense, but after the war the normal peacetime routines were resumed. With the more recent development of nuclear missiles and changing concepts of their use, water utility managements have found themselves in need of information on what precautionary measures to adopt.

The Office of Civil Defense, Department of Defense, has recognized the need for specific information directly applicable to the problem of waterworks operation and recovery. This study is one of many projects sponsored by OCD for the purpose of developing a better understanding of what a nuclear war disaster could do to waterworks utilities and what preparation should be undertaken. The contract under which this study was made provides for an assessment of present Civil Defense preparedness of the waterworks industry. Information is needed concerning the over-all readiness to meet the emergency should it occur now, the competence of the personnel to carry out countermeasures, and the necessary equipment and materials.

To obtain an indication of existing conditions a questionnaire was prepared and submitted to nine large metropolitan water utilities* selected to be

* Appendix A

representative of metropolitan areas throughout the country. The nine areas include a population of more than 20 million, which represents approximately one-sixth of all the population served by municipal water systems in the United States. The nine utilities are in areas considered critical targets. Because of their location, size, and caliber of management, their state of preparedness should represent the maximum to be found in the waterworks industry.

POSSIBLE EFFECTS OF NUCLEAR ATTACK

In preparing the format for a questionnaire consideration was given to the physical elements that make up a waterworks system. These included source, treatment, pumping, storage, and distribution. It was also desired to assess the possible effects of attack on the various personnel functions such as administration, engineering, communication, quality control, and public relations.

The conditions in a war-created emergency may be of two general types. First, there may be contamination from radioactive fallout without structural damage; in this case the water system may remain functionally intact, so that only the health and safety of the utility personnel and the consumers may be affected. (The possibility of the interruption in power from remote sources must not be overlooked for this situation, however). On the other hand the structures may be damaged and the system rendered inoperable in addition to the radioactive contamination. Plans for preparedness must take account of both conditions and include not only the means for minimizing the damage, but must also present methods for making available a supply of water sufficient for survival of the people. In preparing for the first condition, that of radioactive fallout only, emphasis needs to be placed primarily on protection and decontamination of the water supply and on the protection of waterworks personnel. Considered must be not only the hazards of radiation from fallout but also the hazards of biological and chemical warfare. The point of entry of deliberately introduced contaminants may be the source of supply or anywhere in the distribution system. Protective measures therefore require monitoring of the source before the supply is admitted to the system, monitoring of the water in the distribution system, guarding of the physical plant, and protecting the personnel.

Under the second condition, that of blast and thermal radiation damage as well as fallout of radioactive material, plans for protection must include procedures for repair of those facilities that experience damage. Attention must be given to strength of structures, fire prevention, and protection of personnel. Protective measures to increase resistance and reduce damage (referred to as hardening measures in the case of structures) should give attention especially to doors, windows, and other building elements which, if blown in by the over-pressure, could kill personnel and break or destroy equipment and appurtenances necessary for operation. Power and communication facilities need special attention in this respect. Not only may standby power

be required for the operation of the waterworks facilities, it may also be necessary to keep communications operating.

Although many water utilities have experienced emergencies created by natural forces and water utilities are usually designed and built in accordance with accepted standards, there is a need to determine whether there are any weaknesses in the preparedness measures for natural emergencies, as well as for war-created emergencies.

PREPAREDNESS CRITERIA

Natural Emergency

To meet natural emergencies a metropolitan water utility should have

(a) A reliable source of supply protected from water losses and transient contamination;

(b) Treatment works capable of operation under various and changing conditions;

(c) An adequate distribution system capable of being sectionally segregated for repairs without affecting large areas of consumers;

(d) Sources of power adequate to assure operation at all times;

(e) Adequate laboratory facilities to determine the quality of the supply;

(f) A reliable communications system capable of operation in the event of a power failure;

(g) Up-to-date maps, plans and records;

(h) Organized physical security measures in effect;

(i) An adequate staff of trained personnel;

(j) An adequate stockpile of materials, equipment, and emergency supplies;

(k) A plan of operation for time of emergency.

War-Created Emergency

To be prepared to initiate recovery from the effects of nuclear war (blast and shock, initial radiation, thermal radiations and nuclear radiations from fallout) a utility should have, in addition to the above:

(a) A Civil Defense survival and recovery plan;

(b) Provision for sheltering personnel from the effects of fallout and for decontamination in the operating areas;

(c) Structures hardened to resist blast over-pressures and avoid damage to equipment;

(d) Detection equipment and procedures for determining the extent of radiation resulting from fallout;

(e) Equipment and procedures for determining the dose rate and accumulated radiological dose of personnel;

(f) Trained auxiliary personnel to assist in the restoration operation;

(g) Auxiliary power sources which may be put in operation at short notice;

(h) A communication system hardened to resist the effects of nuclear weapons;

(i) An adequate supply of materials and equipment to repair facilities and restore operations;

(j) Mutual aid agreements to provide available assistance when needed.

QUESTIONNAIRE

The criteria and the format for the questionnaire reflect the ideas of many waterworks officials and others experienced in the field. Available waterworks personnel and Civil Defense Directors were consulted. The U.S. Public Health Service, being specifically charged in the National Water Plan with responsibility for assuring water supply availability in time of emergency and having made some assessments of waterworks, made numerous and valuable suggestions. The Office of Civil Defense gave appreciated suggestions. State and local health department engineers also contributed to the basic considerations.

The questionnaire was divided into 15 sections as follows:

1 - Consumer Inventory

2 - General Considerations

3 - Records and Inventories

4 - Security

5 - Communications

6 - Personnel

7 - Training

8 - Mutual Aid

9 - Distribution System

10 - Distribution Storage

11 - Source of Supply

12 - Treatment

13 - Pumping

14 - Laboratory

15 - Public Relations

Questions were asked regarding the existence of any State or regional planning and its relationship to local planning. Questions were also included to determine if tests of the emergency plan had been made through "dry-run" exercises in the "alert" and "post-attack" phases.

To assess preparedness as expressed in the questionnaire a rating system was developed. Although each utility must develop its plan to fit its particular needs, the end result should b.. the same in all cases, i.e., to have the physical plant in a condition to resist the destructive forces; to have key personnel sheltered and trained to act promptly and efficiently; to have the ability to communicate both within and outside the utility even when normal lines of communication are destroyed; and to have essential material and equipment stockpiled and available.

For rating purposes values were assigned as follows:

General Preparation	25
Personnel	25
Communications	20
Hardening	15
Mutual Aid	15

The fifteen items into which the questionnaire was divided were evaluated with respect to over-all preparedness. The physical capability of the utility for operation and recovery were considered as well as certain other aspects which would affect maintenance of service. In those systems which include pumping, service could not be long maintained during a power failure without independent stand-by facilities. Similarly, in an emergency availability of personnel, ability to communicate, and the functioning of laboratory facilities will materially influence the ability to continue operations.

To differentiate further between preparedness for the natural and war-created emergencies, the questions were grouped under various sub-headings which would reveal "Natural Disaster Preparedness" and "War-created Preparedness". No specific rating values were applied to these groups. The "Yes" answers to the questions were used as the basis for the analysis.

Under the general heading of "Natural Disaster Preparedness" the questions were grouped under subheadings of:

Pumping, including power

Treatment

Distribution

Quality control (laboratory)

Engineering

Communications

Inventory

Public relations

Under the general heading of "War-created Preparedness" questions were grouped under the subheading of:

Management planning

Facility resistance

Emergency sources, treatment, and distribution

Personnel protection

Mutual aid

"Alert" training exercise

The questionnaire was applied in August 1962 to the water supply systems of the nine metropolitan areas after a general discussion of the purpose of the questionnaire and a review with management and operating personnel of the water system being surveyed. Pertinent publications of the utility were reviewed and inspections of certain elements of the system were made. By this method it was felt that uniformity in interpreting questions would be assured and reliable information obtained.

To complete the assessment a short questionnaire was submitted to the Engineers of nine State Health Departments* to ascertain what natural disasters have been experienced in the various areas and the success with which water utilities have operated during emergencies. In addition, a short questionnaire was completed for each of the nine States showing the status of preparedness for a war-created disaster.

ANALYSIS OF INFORMATION

Since the nine water utilities surveyed serve better than one-fifth of the population served by all the water utilities in cities over 25,000 population and nearly one-tenth of the population of the United States, it is felt that the ratings obtained for the nine indicate the general state of preparedness of the industry.

Personal contacts with management and operating personnel indicated that preparedness was a matter of being able to cope with the natural disaster they are familiar with. Well qualified and trained personnel are in key positions but there appeared to be little or no back-up. The possibility of not having such first line personnel available during an emergency has received only limited consideration. Situations that might arise from conditions of fallout or from blast and fallout have not been planned for.

It appears, in considering the ratings, shown in Table I, that in the area of "General Preparation" all of the utilities are reasonably well prepared to cope with a natural disaster. This condition of preparedness is also reflected in the items of "Communications" and "Personnel". A number of the replies indicate little has been done to develop "Mutual Aid" between the large water utilities of metropolitan areas or to "Hardening".

Pumping

Six of the nine utilities had pumping equipment and necessary appurtenant facilities including on-site storage of fuel and auxiliary power units designed and protected for continuing operation during an emergency although of less than normal capacity. The other three utilities function as gravity

* Appendix B

TABLE I - RATED PREPAREDNESS OF NINE METROPOLITAN WATER UTILITIES

	A	B	C	D	E	F	G	H	I
General Preparation	19	15	17	16	17	19	16	16	17
Personnel	17	12	16	12	9	16	13	16	12
Communications	20	20	20	17	9	20	20	15	13
Hardening	7	6	7	3	5	10	7	5	5
Mutual Aid	7	4	4	4	11	11	7	11	6
Rating based on 100	70	57	64	52	51	76	63	63	53

The values assigned to the sectional groups and the minimum, maximum, and median weighted ratings obtained are shown in Table II.

TABLE II - SUMMARY OF PREPAREDNESS RATINGS

	Assigned Value	Range of Ratings		
		Min.	Max.	Median
General Preparation	25	15	19	17
Personnel	25	9	17	13
Communications	20	9	20	20
Hardening	15	3	10	6
Mutual Aid	15	4	11	7

Analyzing the replies under the second method of grouping the questions, as shown in Table III, the following observations can be made.

TABLE III - PREPAREDNESS OF NINE METROPOLITAN WATER UTILITIES
Based on Questions Selected To Indicate Natural Disaster and War-disaster Preparedness

Natural Disaster Preparedness	No. Q	A	B	C	D	E	F	G	H	I
Pumping	10	8	3	7	9½	7	6	6	3	6
Treatment	7	5	2	6	4	6	6	4	5	7
Distribution	11	8	9	9	10	8½	9	9	9	8
Quality Control (Laboratory)	11	9	8	7	8	10	9	8	10	8½
Engineering	4	3	4	4	2½	3	4	4	4	4
Communications	8	7	7	7	7	3	7	7	5	4½
Public Relations	8	7	3	5	3½	6	6	5	5	6
Inventory	8	7	3	4	5	3	7	5	6	5
Total	67	54	39	49	49½	46½	54	48	47	49
% of Replies Indicating Preparedness		81	58	73	74	69	81	72	70	73

Median Value 73

War-disaster Preparedness	No. Q	A	B	C	D	E	F	G	H	I
Management Planning	11	9	7	6½	8	8	8½	8	5	5
Facility Resistance	12	4	8	6½	2½	2	10	6	6½	6½
Emer. Sources, Treatm't, Dist.	15	6	6	7	7	5	7	6½	5	7
Personnel-Emer. & Auxil.	21	17	13	17	9½	11	18	15	15	12½
Personnel Protection	5	2½	0	0	1	0	2	0	½	1
Mutual Aid	10	4	2	2	2	5	6	4	3	1½
"Alert"	23	19	13	10	6½	9	18	10	13	8½
Total	97	61½	49	49	36½	40	69½	49½	48	42
% of Replies Indicating Preparedness		63	50	50	38	41	72	51	49	43

Median Value 50

systems capable of maintaining a supply without pumps or power and one of the six could function at approximately two-thirds capacity without pumping during an emergency.

Treatment

In general all the utilities have considered changes or modifications in chemical dosage and treatment for the conditions most likely to occur in a natural disaster.

Distribution

The distribution systems were reported to be adequately designed and maintained. Available private supplies have been inventoried in some areas and although not connected to the distribution system are considered as capable of providing a source of substitute water. The water utilities surveyed generally appear to avoid interconnection to sources of supply not operated entirely under the control of the utility.

Laboratory

All laboratories were adequately equipped for the job at hand including the control of quality under modifications of treatment necessary to meet changes in the raw water quality induced by weather or by wastes released to watersheds upstream from surface water intakes. Monitoring for radioactive ionization was reported by some of the water utilities. In some cases monitoring was reported where samples were sent at stated intervals to a testing laboratory.

Provision of standby power and an emergency source of water for the laboratory had not been made and there were no indications that the protection of laboratory personnel from blast and thermal radiation or from fallout had been provided.

Engineering

Maps, plans, valve books, and pertinent maintenance records were generally maintained in an up-to-date condition with duplicate copies distributed to valve crews and to mobilization centers.

Communication

Facilities to communicate appeared to be well developed for normal operations and the "normal" emergency. Radio communication with maintenance shops, warehouses and repair crew cars and trucks generally were provided through a base station. In many instances tie-in with the police, fire and Civil Defense communication systems was indicated. Many utilities

have two or more "base stations". Lack of standby or auxiliary power at base stations was noted. One utility had a "hardened" base station. All utilities reported communication between mobile units was possible without the base station.

Public Relations

Procedures for keeping the consumers informed of conditions and water quality were generally good. Only one of the nine utilities indicated that there were no such procedures established.

Inventory

There has been preparation for an emergency through inventory and stockpiling of materials and supplies that would enable the utilities to be self-sufficient for a limited period, however, the recommended 30 day supply of all items is, in many instances, not available. Some utilities have a six month supply, or more, on many of their material needs. Chemicals for water treatment generally are not in excess of 30 days. Due in part to the large quantities used there is, in some plants, only a three to ten day supply normally maintained. This is especially true of the chlorine supply.

In similar manner emergency treatment facilities were indicated to be available but when the size or capacity of the equipment was considered they appeared to be inadequate for the probable need. There was little or no interest apparent in joint stockpiling with other utilities.

Management Planning

Seven of the utilities indicated they have an emergency operating plan, for natural disasters similar to those that have been experienced (floods, earthquakes, tornadoes, etc.) however some of these appeared to be only operating procedures. Only four indicated that their plans were based on disasters that may result from modern warfare.

Facility Resistance

Vulnerability studies of the system to blast damage and radioactive contamination has been made by five utilities. Four utilities (including two of the five above) have formulated procedures for damage assessment and for estimating personnel, equipment and materials needed for restoration. Two have made studies for improving the resistance of the treatment and pumping works to weapons effects but very little consideration has been given to the protection of the distribution system storage facilities from contamination or from blast damage. Only one laboratory is said to be protected from blast effect and fallout due to its location in a basement.

Emergency Sources, Treatment and Distribution

Surveys have been made in some metropolitan areas for auxiliary sources of water. A few utilities do have interconnections to other potable supplies. Others indicate there are no interconnections with other water supplies. Hauling water for emergency use is considered by most metropolitan utilities to be the job for other Civil Defense units.

Eight utilities have emergency chlorination equipment but only three have more complete mobile purification units available for treating contaminated water. One of the three has plans for use of the mobile purification unit to supply a critical need such as a hospital.

In general, methods for emergency rationing and water distribution during disaster by improvised methods has been considered and planned for, however, only two have inventoried critical consumers such as hospitals, food processors, etc., the industrial users who would have priority for defense purposes and the users whose supply could be curtailed or shut off during the emergency.

Mutual Aid

Although six utilities report the existence of a Mutual Aid agreement, there are no programs for mutual aid training of personnel. Only two report standardization of emergency equipment and material and in only one instance do the parties to the agreement know where plans of the other system(s) are maintained. Aside from the two cases where interconnections do exist only one reports an interconnection with an industrial or other private supply contemplated. In only two instances is joint stockpiling of equipment and materials or of inventorying what equipment or materials might be available through mutual aid agreements apparent.

Personnel, Availability and Training

All utilities indicated that key personnel had responsibility assignments in time of disaster but not all of them had alternates or lines of succession established. All utilities had designated mobilization centers but only five had considered alternate locations. Lists of personnel with addresses and phone numbers are available but only one has prepared maps showing where they reside. Routes of travel and time required to reach the assigned mobilization centers have not been determined. Two utilities indicated they had inventoried the community for potential auxiliary personnel and one reported a manpower pool to supplement the normal working force during an emergency.

All utilities report their personnel having disaster training and assignments for other operational duties. Personnel have had little training on the character of nuclear weapons and the effects which must be avoided

and only one utility had developed a training program in radiation monitoring for employee protection.

Personnel Protection

Two utilities indicate that shelter areas are provided at critical operating locations although one of these indicates "for headquarters and communication staff only". Two utilities (including one of the above) have determined the protection factor of the potential shelter areas. No shelter areas are stocked with essential survival items and only two utilities have provided radiation monitoring equipment for personnel protection.

SUMMARY OF SURVEY DATA

From the foregoing analysis it is evident that insofar as water utility planning for an emergency is concerned it is generally in the area of natural disasters. Although there are occasional indications that the planning has provided for more severe disasters than have been experienced or reported, none have provided for the extent of damage or loss of personnel that could result from modern warfare.

For the metropolitan water utilities studied, an assessment of the status of preparedness to recover and operate in an area experiencing the character of damage inflicted in a natural emergency indicated a median preparedness value of 73 percent. For damage that may be inflicted by nuclear warfare a median preparedness value of 50 percent was indicated.

Improvised measures for supplying at least some small quantity of water to the survivors and therefore the need to have available emergency equipment has been given little consideration. Assignment of emergency personnel in the chain of command and key operating positions at least three deep in most instances has not been made.

Protective devices, especially shelters for personnel, should the disaster include fallout and a radiation hazard, have not been provided. The fact that personnel may be "pinned-down" at the work stations for several days and will require food, water and other survival items and an ability to communicate with the outside is not provided for.

Although electric power may be supplied from two or more distant sources, the fact that local transmission lines, transformers and switch gear could be lost has not been provided for.

When considering the replies received from the Engineers of State Health Departments, (Table IV), it is again quite evident that present preparedness is related almost entirely to the natural disaster emergency. It will be seen that drought and flood are the most frequently encountered

TABLE IV - WATERWORKS PREPAREDNESS AS INDICATED BY ENGINEERS OF STATE HEALTH DEPARTMENTS

Type of Disaster Experienced	L	M	N	O	P	Q	R	S	T
Hurricane			x	x				x	
Tornado			x	x	x				
Flood	x	x		x		x	x	x	
Drought	x	x		x			x	x	x
Fire	x			x	x				
Other (Earthquake, Tidalwave, Industrial Accident)	x			x	x				
Water utilities have satisfactorily met water needs during disasters.	x	x	x	x	x	x	x	x	x
Assessment of Emergency Preparedness									
1. Systems are reviewed for ability to serve water during emergency.			x	x	x			x	
2. Waterworks operators understand treatment methods for CBR.	x			x			x		x
3. Equipment available for detection of CBR contamination.	x								
4. Treatment facilities available to cope with CBR contamination.									
5. Chemicals available for one month's treatment.		x		x					
6. Equipment available to detect external radiation hazard to personnel.	x		x				x		x
7. Personnel trained to operate in fallout radiation hazard areas.									
8. Fallout shelters provided for key personnel.					x				
9. Utilities prepared to serve quality water during war emergency.				x			x		

Note - "x" indicates affirmative reply.

emergencies, and hurricane, tornado and fire less frequently experienced.

Only four of the nine states indicate that water utility systems have been reviewed for ability to supply water during a Civil Defense disaster.

One state indicates equipment available for the detection of radiological contamination, although four states indicate that equipment for the detection of external radiation hazards to personnel is available.

Two states indicate that chemicals to provide water treatment for a 30-day period are available, and two states indicate that they feel that waterworks utilities are prepared to serve quality water during periods of disaster which might result from war or sabotage.

CONCLUSIONS

It is evident that in the large metropolitan areas:

(1) Water utilities are prepared to handle conditions created by such national disasters as have occurred in the area of the utility.

(2) Water utilities are not prepared for the more severe war-created disasters including nuclear warfare.

(3) Water utilities are not prepared to operate in areas experiencing heavy radioactive fallout, (early fallout).

(4) Water utilities are not prepared to operate in areas contaminated by biological warfare and chemical warfare agents.

(5) Water utilities do not have the emergency water treatment equipment in size or in numbers sufficient to provide potable water in extreme war-created emergencies.

(6) Water utilities generally have not inventoried the source and location of auxiliary supplies that might provide subsistence water in an emergency.

(7) In metropolitan areas methods for supplying water in emergencies involving prolonged interruptions in the piped water supply have not been provided.

(8) Water utilities have not provided for the protection of operating personnel from radioactive fallout.

(9) Water utilities have not made provision for supplementary personnel to assist in recovery.

(10) Water utilities have not made provisions to assure operation of the control laboratories during a war-created disaster.

(11) Although most utilities indicate that personnel have had disaster training and job assignments for an emergency and that Mutual Aid agreements are in existence it is evident that such training, job assignment and aid agreements are generally based on natural disasters and need hardening for war-created disasters.

Additional and more extensive planning is necessary with greater attention given to:

(a) Training of personnel in handling CBR contamination,

(b) Training personnel in understanding the hazards of radiation and protection from it,

(c) Hardening of power facilities to insure continuous operation,

(d) Hardening of communication facilities,

(e) Treatment facilities to provide maximum flexibility in operation,

(f) Strengthening structures to resist blast effects,

(g) Recruiting and training auxiliary personnel,

(h) Improving Mutual Aid and Joint Venture agreements to insure assistance from other utilities,

(i) The source of supply before it enters the system, and the stockpiling of operating supplies and materials,

(j) The establishment of a Civil Defense section within the metropolitan water utility with a full time staff for research, development, planning and coordination of the Advance Preparation program.

CHAPTER IV

POST ATTACK RECOVERY AND EMERGENCY OPERATION IN CIVIL DEFENSE DISASTER

The development of nuclear energy and the threat of nuclear warfare have created new problems which waterworks men must consider in the construction and operation of water supply systems. Severe blast and shock damage, even the complete destruction of waterworks facilities over extensive areas; the possibility of many of the key workmen being incapacitated in one short instant; the possibility of all the surviving workmen being confined for days to locations affording shelter from radioactive fallout and essential waterworks facilities going unmanned, are possibilities which must now be considered in the development of a water supply system and in formulation of procedures for emergency operation.

Absolute total protection of the waterworks facilities from the effects of nuclear weapons is not attainable, nor is the absolute protection of waterworks personnel. Nevertheless it is possible to provide protection of such character and extent that, when coupled with other improvised emergency measures for the supplying of water, the essential post-attack survival needs can be met. To provide this degree of protection waterworks operators must understand the character and magnitude of the effects of nuclear weapons and must know what countermeasures will minimize the effects and facilitate recovery. They must understand methods of utilizing the full potential of the utility for emergency operation and recovery under post attack conditions. With these principles in mind the utility management must act to strengthen the disaster organization, operational plan, and the waterworks system itself.

Waterworks planners will never know when to expect a nuclear attack, nor be able to predict the nature and extent of damage. Nevertheless, pre-attack judgment estimates and assumptions will have to be made on these matters in order to have a basis for planning and advance preparation. Effective post-attack recovery begins with advance preparation.

ADVANCE PREPARATION

The many considerations necessary in the pre-attack development of a state of readiness of waterworks are presented in outline form in Chapter VI - Guide to Advance Preparation. Of all these measures presented, the ones which will most significantly determine the effectiveness of early recovery and emergency operations are those that influence the response of structures, facilities, and personnel to blast and shock effects; of structures and personnel to thermal radiation; and of personnel to initial and fallout radioactivity.

The objective of preparedness measures is to assure a supply of water throughout the attack and disaster recovery period which will be adequate to maintain the life of those individuals that survive the initial effects of the attack. Water must be available in areas of need for drinking, fire control, radiological decontamination, and the recovery of essential industry. This may be accomplished by preventing damage to the water supply, the system, and operating personnel. Alternatively, water may be provided during the disaster by means not normally used, such as emergency stored water or an alternate source and supply system.

Advance preparation to assist in fulfilling this objective should include the following:

1) A staff especially trained in emergency operations and recovery of the waterworks under post-attack conditions;

2) A Civil Defense organization plan;

3) A disaster operational procedure;

4) Shelters for essential personnel at locations that will facilitate emergency operations and recovery;

5) Hardening of structures and facilities to minimize damage;

6) Stockpiling of essential equipment, material, and supplies in sheltered locations to facilitate emergency operations and recovery;

7) Inventorying and planning (Mutual Aid) for use of alternate supplies;

8) Radiological protection.

Personnel

Waterworks personnel should be familiar with the organizational plan and trained in operational procedures. There should be, at all times, a staff of key personnel in such locations that they are sheltered from the effects of nuclear weapons (blast and shock, thermal radiation, initial nuclear radiation). Means should exist for mobilizing the full complement of men in accordance with the emergency plan should an alert be sounded or a surprise attack occur.

It is not normal practice in the operation of water supply systems to have personnel stationed in sheltered locations in the manner of firemen awaiting calls. In fact, the nature of the water works operation precludes to a very large extent such sheltering of workmen, since much of the work must be performed in exposed locations. A portion of the waterworks staff is normally maintained in a state of readiness to respond when emergency conditions

demand, but even these men are generally occupied on low priority routine work until called. The mobilization plan must be flexible enough to provide for the various conditions including the assembling of off-duty personnel.

The management has very limited control of the effectiveness of measures to protect waterworks personnel and to insure their availability at locations of need in the early post-attack period. While structures may be hardened and materials stockpiled to provide a constant protection factor, the vulnerability of the employees varies continuously with their activities. Only when a man is sheltered at his designated work station is his protection of the same order as that of hardened structures. The establishment of shelters and a mobilization program assuring that key employees are in them at the time of attack is of utmost importance.

The provision of shelters in the immediate vicinity of critical waterworks facilities which are manned with operators at all times will facilitate the mobilization of the on-duty operating personnel if the warning period is sufficient for such personnel to take shelter before attack. However those personnel who happen to be so far removed from their designated shelter at time of warning that they do not reach the shelter by the time of attack may be no more available in the post-attack period than the off-duty personnel. It must be recognized that personnel not sheltered at time of attack in the vicinity of the location where they will be needed in the early post attack period will be available only if they survive the initial effects and can get to their assigned location without exposure to excessive radiation.

Areas escaping physical damage from a nuclear attack may still receive hazardous amounts of fallout material. It may be possible under some conditions to mobilize personnel in the early post-attack period before the fallout arrives, and the operational plan should provide for this. The mobilization of distant personnel will necessarily proceed only as the conditions of damage and fallout (with decay) permits.

The importance of having key waterworks personnel in shelters at the time of attack at locations from which they can work effectively in the early post-attack period becomes apparent. The preparation of shelters, the development of a plan of mobilization including an emergency staff on duty at all times, and the training of employees in procedures to carry out the mobilization plan under various circumstances will reduce the time it takes personnel to get to their assigned shelters and thus assure a greater number being available. Few systems will continue to produce potable water if personnel suddenly cease to carry out certain manual operations, or continue to deliver water at all if preventive maintenance operations are not carried out. This will be especially true under war-created conditions even for automated systems.

Knowledgeable waterworks men adequately trained to restore and operate in the post-attack environment can be developed. This is technically possible as well as financially feasible. It is a vital part of Civil Defense advance preparation to provide such personnel. Administrative and supervisory personnel will have to accept new responsibilities and duties, and should receive appropriate training. A chain of command should be established with alternates three deep in each key position. Supervisory and experienced waterworks personnel will be the backbone of the staff involved in the early appraisal of damage and in the planning of recovery and repair operations.

All utility personnel will benefit from training in basic civil defense. Special training to improve the competence of the supervisory, operating, and maintenance personnel in emergency water treatment and supply practices and in an understanding of radioactive contaminants is essential. Each employee should be informed as to the nature of a nuclear blast; the extent and nature of the damage which blast, thermal radiation, and fallout can produce; methods of radiation detection and decontamination; and the use of personal exposure radiation measuring equipment. The names, addresses, telephone numbers, normal work assignments, emergency operation trained for, etc. should be maintained both at administrative offices and at the assembly areas. Procedures for reaching personnel day or night should be worked out. Some of this information on map overlays will facilitate assembly of available personnel.

Personnel will be exposed to all of the effects of a nuclear attack, lessened only to the extent that protection is actually provided. The protection factor of shelters therefore is important. Every effort should be made to kpep the radiation dose receivable within the shelter as low as possible in order to permit personnel to enter contaminated work areas earlier and stay longer. Provisioning of the shelters is also essential. Adequate equipment and supplies to maintain employees in good physical and mental condition must be provided. Means of communication with command and control posts must be available to implement decisions, to maintain continuity of authority, and power-assure organized action.

Facilities

Just as important as providing every possible protective feature fo assure personnel being available after an attack is the necessity of preserving the facilities and equipment. The source of supply may be inexhaustible, and the treatment plant most flexible as far as operation is concerned. There may be distribution storage in all populated areas. But every such feature has its weak links.

Power to many portions of the system is essential to operation but in an attack it is one of the first likely failures because of vulnerability of transformers and switch-gear at the facility itself. Disinfection is essential in the

production of a potable quality water but even a very low overpressure under certain conditions can damage and interrupt the operation of such equipment. Telemetering and other automation equipment upon which much of present day operation depends will be affected by relatively low overpressures.

To ascertain the weak links in the system and their relation to the over-all possibility of supplying needed water post attack requires a vulnerability assessment of the entire system. Each component must be studied and a determination made as to its ability to withstand the various levels of attack and the resulting forces to which it will be subjected. Such a study will permit decisions to be made as to whether duplication would be desirable and could be accomplished; whether separation to widely dispersed locations would be desirable; whether hardening of structures should be attempted; and whether adequate flexibility of operation has been provided.

Vulnerability

The destructive effects of a nuclear explosion on the structures are due to blast and shock forces and, to a lesser extent, thermal radiation. Other destructive effects, particularly those on personnel and the water supply, are the initial radiation and radioactive fallout. These nuclear weapon phenomena have been studied, and the magnitudes of the several effects to be expected have been determined. Data are also available on the resistance of various structural materials, and it is therefore possible to estimate the results of a given blast. Units of measurement used for the several destructive phenomena are as follows:

Primary Phenomena	Unit of Measurement
Shock Overpressure	Lb/in^2 (psi)
Thermal Radiation	$Calories/cm^2$ or $Cal/cm^2/sec$
Initial High-Energy Radiation	Roentgen or Rads
Fallout	Roentgen/hour

The areas affected by the blast and shock, and by thermal radiation from a 5 megaton surface burst are shown in Table V. The significant effects created by the various overpressures and thermal radiation are given as an indication of the extent of the area in which protection must be provided. Templet overlays, showing effects of detonations, for water utility maps prepared in advance would be helpful in initiation of effective post-attack planning.

To assist waterworks personnel in making vulnerability studies, a form is suggested (Form I), on which the overpressures causing various

TABLE V RANGE AND EFFECT OF A 5 MT BOMB (SURFACE BURST)

Radii	Area	Overpressure	Effect
1 Miles	3 Sq. Miles	50 psi	Complete demolition all above ground structures.
2	12	25	Severe damage all above ground structures.
3	30	10	Moderate damage to reinforced concrete (not earthquake resistant) structures.
4.5	60	5.0	Building walls crack. Moderate damage water lines and fire hydrants. Telephone & power lines down.
6	100	3.5	Damage interrupting filter operations. Service connections damaged.
7	150	2.5	Roofs of structures collapse. Moderate damage motors, pumps, piping.
8	200	2.0	Moderate damage telemetering and telephone systems.
10	300	1.5	Chemical equipment damaged.
13	500	1.0	Light damage to switch gear resulting in loss of power.
20	1200	0.5	Windows and doors blown in. Disinfection may be interrupted.
		Thermal Radiation	
13	500	12 cal/cm^2	Exposed skin-3rd degree burns. Wood chars.
15	700	8	Exposed skin-2nd degree burns.
20	1200	5	Cotton awning canvas ignites.
24	1800	3	Combustible materials in homes ignite.

FORM I - VULNERABILITY ASSESSMENT FORM - CHLORINATION PLANTS

NAME OF PLANT: CHLORINATION PL. # 1 NO. & TYPE UNITS: 2 - 400 # W & P SOL. FD.
TYPE CONSTR.: Reinf. Conc. REPAIR PRIORITY: ______________

(NUCLEAR WARFARE WITH RADIOACTIVE FALLOUT)

	PSI OVERPRESSURE (At which indicated degree of damage occurs)										
	.5	1	2	3	4	5	6	8	10	12	16
POWER SERVICE											
Power Co. system temp. outage (to 3 days)			x								
Power Co. system outage (to 1 month)				x							
Power Co. system outage (1 month plus)					x						
Local transformer and service outage (to 3 days)			x								
Local transformer and service outage (to 1 month)				x							
Local transformer and service outage (1 month plus)					x						
BUILDING DAMAGE											
Windows and doors blown in, some missile damage	x										
Walls cracked, walls partially blown in, considerable missile damage, much debris					x						
Walls shattered, incipient collapse, much missile and debris damage, extensive rebuilding necessary							x				
FIRE DAMAGE											
Minor fire damage probable											
Destruction by fire probable											
CHLORINE GAS HAZARD											
Extensive damage to plant chlorine storage area, scales, etc. liquid chlorine lines broken, tank valves broken, severe gas hazard					x						
CHLORINATION EQUIPMENT											
Minor damage from missiles & debris, leaks in tubing and glass components			x								
Moderate damage from missiles & debris, leaks in plastic or rubber solution feed lines, up to 3 days required for clean-up and repair					x						
Severe damage, tubing broken, chlorinators damaged beyond repair piping and valving damaged severely							x				
HIGH PRESSURE WATER SUPPLY											
Temp. outage (to 3 days)			x								
Prolonged outage (to 1 month)				x							
Extended outage (1 month plus)					x						
TELEMETERING, AUTOMATIC CONTROLS, INSTRUMENTATION, etc.											
Light damage, local repair possible within hours		x									
Moderate damage, failure for up to 1 week			x								
Severe damage, failure for extended period, bypassing or replacement necessary					x						
OTHER DAMAGE											

FORM I - VULNERABILITY ASSESSMENT FORM - RESERVOIRS

NAME OF PLANT: Reservoir No. 1

TYPE, UNITS, & CAPACITY: Distribution - 10 M.G.

TYPE OF CONSTRUCTION: Reinf. conc. buried, 1 ft. earth cover

REPAIR PRIORITY: Secondary

(NUCLEAR WARFARE WITH RADIOACTIVE FALLOUT)

PSI OVERPRESSURE
(At which indicated degree of damage occurs)

	.5	1	2	3	4	5	6	8	10	12	16
POWER											
Temporary outage (to 3 days)			x			(lighting only)					
Prolonged outage (to 1 month)				x			"				
Extended outage (1 mo. plus)					x		"				
CONTROL VALVES, OUTLET TOWERS, ALTITUDE VALVES											
Light damage to float switches, altitude valve control systems, gate operators, etc. local repair possible					x						
Moderate damage to control systems etc. Moderate damage to valves due to manhole cover collapse, outlet tower blast damage, etc.						x					
Severe damage to controls and valving, major repairs or replacement required. Severe structural damage to towers, manholes & exposed piping								x			
RESERVOIR STRUCTURAL DAMAGE											
Light damage, roof bent & cracked but essentially intact, vent screens blown in, etc.			x								
Moderate damage, Roof partially collapsed					x						
Severe damage, roof completely collapsed, side walls cracked, possible shifting of embankments, side walls, etc. causing leak developments, damage to outlet line, etc. drainage or partial drainage required for safe operation							x				
BOAT & DOCK DAMAGE											
Boat slightly damaged, light damage to dock, fuel storage, and storage buildings											
Severe damage to boat & docking facilities, possible fire in fuel storage facility											
WAREHOUSES, CARETAKERS HOMES, GARAGES, ETC.											
Light damage, local repair possible in 3 days											
Moderate damage, extensive clean-up and repair necessary											
Severe damage, probable fire and complete destruction											
TELEMETERING SYSTEM											
Light damage			x								
Moderate damage				x							
Severe damage					x						
OTHER DAMAGE											

Form I - Sheet 2

degrees of damage can be shown. The extent of damage experienced from various overpressures on a chlorination plant in a reinforced concrete building and on a buried, reinforced concrete reservoir are shown. Similar forms may be developed for each unit or facility.

The chlorination plant form indicates the following:

a) For a 0.5 psi overpressure, the windows and doors are blown in causing damage to equipment. Effective operation may be interrupted.

b) For a one psi blast overpressure, the telemetering system suffers slight damage, and greater damage occurs to chlorination equipment. Interruption in effective operation probable.

c) For a two psi overpressure, there will be a temporary power outage which will cause failure of the high-pressure water supply. Minor damage to power equipment will occur. Interruption in effective operation certain.

d) For three psi of overpressure a power outage of up to one month may be expected, and the damage conditions which are shown as occurring at lower overpressures will be more severe.

e) The analysis can be continued for higher overpressures to the point where the building collapses at about six psi.

With such information available for all facilities damage criteria can be established and determinations made not only of the type of damage at various overpressures, but also the repair methods and equipment and materials needed to initiate recovery and restoration. A form is suggested for this purpose (Form II, "Damage Criteria for Waterworks Facilities"). This form is useful also in determining the type of training which operating and maintenance personnel should receive.

Hardening

Hardening includes any measures taken to strengthen a system so that the vital parts will resist the damaging effects of attack. In the case of structures, the type and extent of protective construction employed will depend on the importance of the structure in providing water during the disaster. The degree of damage each part of the system may experience can be determined by predicting the response to various overpressures applied. When all the overpressure effects have been assembled, decisions can be made as to what units should be hardened and to what overpressure; the criterion will be that enough of the system survive the attack to supply the water needed. Knowing the condition and vulnerability of the system pre-attack

FORM II - DAMAGE CRITERIA FOR WATERWORKS FACILITIES

CHLORINATION PLANT - Reinf. Conc. Constr.

Damage Rating	Light Damage	Moderate Damage	Severe Damage
Approx. Over-pressure range	0.5 -3 0 psi	3-6 psi	6 psi up
Description of Damage	Doors & windows blown in, possible missile damage to chlorinators, instruments, chlorine lines, etc. Probable temporary power failure with loss of automatic controls, high pressure water	As in light damage except more severe. Walls partially cracked, partial roof collapse likely. Damage to chlorine cylinders and lines causing chlorine gas leaks	Walls shattered, incipient collapse, probable extensive missile damage, extended power outage
Repairs necessary in probable order of importance	Repair chlorine leaks, restore power and high pressure water systems. Repair or replace instrumentation. Debris clean-up and building repair	As in light damage except that repairs will be more extensive. Immediate attention to chlorine gas leak control	Extensive overall repair probably necessary. Immediate repair of chlorine leaks should be made.
Time Required to return plant to operation	One to three days depending on damage to critical components	3 days to several weeks	Indefinite
Priority of Repair in relation to overall system	Top priority	Top priority	Top priority (use of emergency equipment)
Possible Improvisations	Bypassing of automatic controls, use of portable gasoline powered pump for high pressure water. Change of point of chlorine applications, such as directly to reservoir, suction site of pumps, etc. Direct feed of chlorine from tank to reservoir. Use of liquid or powdered hypochlorite may be feasible in small installation. Use of standby and emergency equipment.	As in light damage. For chlorine leak control rotate cylinders to let gas escape rather than liquid. Use of special clamps for controlling leaks. Use of wooden or metal plugs on small holes (Refer to chlorine institute emergency measures)	Use of alternate plant or substitution of portable emergency equipment. Also, as moderate damage.
Recommended Stockpile Items	Gasoline powered pump for high pressure water systems. Hypochlorite powder. Liquid chlorine, emergency standby chlorinators. Gas Masks. Normal plant maintenance items. Caustic soda for absorbing liquid chlorine.	As in light damage	As in light damage.

FORM II - DAMAGE CRITERIA FOR WATERWORKS FACILITIES

RESERVOIR, DISTRIBUTION - Reinforced concrete construction. Reinforced concrete roof at or near ground level

Damage Rating	Light Damage	Moderate Damage	Severe Damage
Overpressure Range	1to 3 psi	3-6 psi	6 psi plus
Description of Damage	Vent openings blown in Probable missile damage to exposed appurtenances such as telemetering, transmitters, lighting, fencing. Possible collapse of metal hatch & manhole covers. Reservoir should remain operable.	Roof slab badly cracked with extensive spalling of concrete. Portions of roof collapsed. Other damage as in light damage. Possible damage to outlet valves & piping due to manhole cover collapse. Reservoir should remain in service.	General roof collapse, into water. Roof top appurtenances destroyed. Possible shifting & cracking of embankments & sidewalls with development of leaks. Probable dam age to outlet valves & piping due to manhole roof collapse & missile damage.
Repairs needed in probable order of importance	Clearing of damaged hatch & manhole covers to allow access to valves etc. Repair of vents & other appurtenances.	As in light damage. Debris cleanup. (debris should settle to bottom where it could be left indefinitely)	Immediate repair of leaks. Attention to safety of embankments. Major rebuilding required.
Time required for return to operation	Reservoir should remain operable	Reservoir should remain operable except for damage to valving, etc.	Extended period of time.
Priority of repairs as compared to overall system	High priority to repair of critical items such as valving.	As in light damage	None, probable temporary abondonment. Emergency control of any flood hazard is imperative.
Possible Improvisations		Operation without roof repair feasible. Provide chlorine residual.	Immediate partial drainage and operation at reduced capacity. Also, measures as in Moderate Damage.
Recommended Stockpile Items		Chlorine equipment and supplies	Chlorine equipment and supplies

Form II - Sheet 2

FORM II - DAMAGE CRITERIA FOR WATERWORKS FACILITIES

RESERVOIR, DISTRIBUTION - Concrete or gunite construction with steel or wood frame roof with sheet metal covering.

Damage Rating	Light Damage	Moderate Damage	Severe Damage
Overpressure Range	.5 to 2 psi	2 psi to 3 psi	3 psi and up
Description of Damage	Severe bending of sheet metal roofing. Damage to appurtenances attached to roofing.	General collapse of sheet metal roofing into reservoirs. Some damage to columns, girders, joists and struts. Appurtenances on roof or within reservoir in exposed locations will be severely damaged. (Such as float type staff gages, telemetering transmitters, float switches water stage recorders altitude valve controls, etc.)	Complete collapse of roof & roof framing. Destruction of all appurtenances on roof or within reservoir in exposed location. (as in Moderate Damage)
Repairs needed to return to operation	Reservoir should remain operable.	Repairs to critical appurtenances. Debris cleanup (reservoir may be operated as an open reservoir). Removal of painted or creosoted roof framing members from water probably necessary.	As in Moderate Damage
Time Required to Return to Operation		One to three days	Three days to several weeks
Priority of Repairs as Compared to overall system	High Priority	High Priority	High Priority
Possible Improvisations		Operation as open reservoir. By-passing of appurtenances such as altitude valve controls with hand operation. Chlorination required.	As in Moderate Damage
Recommended Stockpile Items		Emergency chlorination equipment & supplies.	As in Moderate Damage

'Form II - sheet 3

FORM II - DAMAGE CRITERIA FOR WATERWORKS FACILITIES

PUMPING PLANT, BOOSTER, ELEC. - Reinforced concrete construction, earth-quake resistant design, minimum openings, overhead power service

Damage Rating	Light Damage	Moderate Damage	Severe Damage
Overpressure Range	1-2 psi - earthquake resistant design 1-2 psi - non-earthquake resistant design	2-8 psi - earthquake resistant design 2-4 psi - non-earthquake resistant design	8 psi plus - earthquake resistant design 4 psi plus - non-earthquake resistant design
Description of Damage	Windows & doors blown in, possible missile damage to exposed switchgear & appurtenances. Power outage for short period. Exposed transformer racks & cutouts may be damaged. Probable telemetering failure.	Walls cracked, frame distorted, extensive spalling of concrete. Considerable missile and debris damage to switchgear, pumps, motors, appurtenances. Major damage & extended outages in power service & telemetering systems.	Walls badly cracked, severe frame distortion, collapse. Damage as listed under moderate damage except more severe.
Repairs needed (in probable order of importance)	Restoration of power service (Power dept. cooperation necessary). Repairs to critical switchgear & appurtenances. Telemetering system repair, building repair.	As in light damage except that extensive replacement of damaged items will be necessary and debris cleanup required.	As in moderate damage, except more extensive. Extensive rebuilding required.
Time Required for Return to Operation	1 to 3 days approx. Power system repair will be critical item.	Three days to several weeks. Normal power systems will be severely damaged resulting in extended power outage.	Indefinite
Priority of Repair as compared with overall water system	Repair will probably follow transmission & distribution system break control.	As in light damage	As in light damage for critical plants. Probable abandonment of non-critical plants
Possible Improvisations	Use of portable gasoline powered units using emergency connections. Use of portable generators (for smaller units, prior design & planning required). Bypass telemetering & automatic controls.	As in light damage except that extensive damage will require attention to critical pump units first. Probable extensive substitution of switch-gear.	Use portable pumping units and bypass plant completely.
Recommended Stockpile Items	Portable Pump unit with wide head capacity characteristics. Cap. from one-half to one-tenth ave. daily rate. Portable generator. Six mo. supply of normal maintenance items. One month's supply of fuel, oil, etc. for portable units. Steel pipe, fittings, and emergency bypasses.	As in light damage	As in light damage.

Form II - Sheet 4

FORM II - DAMAGE CRITERIA FOR WATERWORKS FACILITIES

DISTRIBUTION SYSTEM - Distribution Mains & Appurtenances

Damage Rating	Light Damage	Moderate Damage	Severe Damage
Overpressure Range	2-5 psi	5-10 psi	10 psi up
Description of Damage	Minor damage to mains. Some Debris damage causing breaks in fire hydrant risers (several per sq mi). Some debris problem in locating gate cans, manholes, etc. Partial collapse of regulator or valve vaults causing damage to vulnerable control piping, operators, etc. Some loss of pressure in system. Complete outages in local areas only.	Development of a number of small leaks and several major main breaks per sq mi of service area. Severe debris damage to fire hydrants with up to 5 major fire hydrant breaks per sq mi. Severe damage to vulnerable regulator or other vault covers causing damage & breaks in up to 25% of regulators & valves. Severe pressure reduction in most of system. Complete outage in up to 25% of service area.	As in moderate damage except more severe. Major debris problem in built-up areas.
Repairs needed in probable order of importance	Control breaks in fire hydrant risers by shut off of control valves. Repair damage of regulator & valve vaults. Repair leaks.	Control main & fire hydrant breaks by shut-off of control valves or isolation of portions of system. Repair or bypass critical regulator stations. Remove debris from critical valves, etc. Repair breaks & major leaks. Repair fire hydrant risers, manhole covers, etc.	As in moderate damage except isolation of larger areas will be required to control loss of water.
Time Required to return to Operation	Basic distribution system should remain in service. Some loss of pressure for short period of time.	Pressure loss & outages can be corrected in several weeks provided storage & pumping system is restored.	Several months required for correction of pressures & outages. Storage & pumping facilities will probably govern time of restoration of complete service.
Priority of repair as related to overall system	Control of major leaks and breaks will have top priority in order to conserve water	As in light damage	As in light damage
Possible Improvisations	Temporary isolation of damaged areas by operation of valving. Reduction of pressures. Use of temporary pipe or fire hoses to bypass leaks or breaks.	Isolation of damaged areas. Possible isolation or reduction in pressure for entire system until major damage areas can be repaired or isolated. Also, as in light damage.	As in moderate damage.
Recommended Stockpile Items	Pipe repair items such as repair clamps, sleeves, plugs, & necessary materials & tools. Welding equip. & materials, portable pipe, hose, with common adapter fittings, extra supply of gate keys, gate books, distribution system drawings, etc. Regulator & valve repair items.	As in light damage	As in light damage

FORM II - DAMAGE CRITERIA FOR WATERWORKS FACILITES

DISTRIBUTION SYSTEM - Services

Damage Rating	Light Damage	Moderate Damage	Severe Damage
Overpressure Range	1-2 psi	2-6 psi	6 psi up
Description of Damage	Numerous leaks and breaks on domestic and fire services due to collapse of buildings. Substantial loss of water until services are shut off.	As in light damage except more severe. Debris problem will delay shutoffs due to valve being covered. Extensive fire damage possible in consumer piping.	General breaks or leaks on majority of services serving all but the most substantial buildings.
Repairs needed in probable order of importance	Shutoff service at house shutoff or at meter. Repair of pipe will be left to consumer.	As in light damage. Isolation of sections of distribution system probably necessary.	As in moderate damage
Time required to return to operation	Will be left up to individual consumer	--	--
Priority of repair as related to overall water system	Control will have high priority	As in light damage	As in light damage
Possible Improvisations	Issue orders for consumers to close shutoff valves. If valves not available, pipe may be bent back or otherwise cramped to reduce flow. Reduce pressure in distribution system.	"	"
Recommended Stockpile Items	Service stop key	As in light damage	As in light damage.

Form II - sheet 6

and the level of effects to which it is assumed each part thereof will be subjected, the post-attack condition of the system can be predicted and methods developed for recovery.

Source of Supply

Water may be available post-attack from sources in use at the time of attack, from water in storage, or from auxiliary or alternate sources of supply. The procedures that are applicable and the time required for the recovery of the source of water is dependent on the character of the facility and its pre-attack condition. Surface sources require special attention. Inlet structures in rivers and lakes may be constructed in such manner that little or no special hardening is required, whereas intakes which are an integral part of a dam or reservoir wall will require careful consideration.

Where the supply is taken from underground sources, the character of the surface structures requires attention. Motors and pump installations on the surface must be protected so that explosions and flying debris do not damage piping, valves, switch gear, wiring, etc. Where submersible pumps are used, little damage may be expected, except to the source of power. In any installation using an electrically driven power unit, the source of energy is the most vulnerable item.

To further assure that water will be available when needed, an inventory of all private, commercial, and industrial water supplies should be made. The treatment necessary to make such sources usable by the surviving population should be known, as well as methods for connecting them to the distribution system or making them available by other methods. Inventorying these supplies will assist in determining the portable pumping, treatment, and disinfection equipment that should be available.

Treatment

Treatment normally practiced may consist only of disinfection or it may include all the items needed for clarification, softening, and color and odor control as well. After an attack it may be possible to operate without some of these features. The objective will be to supply water that can be safely used for drinking.

Hardening of the treatment facilities must be directed to insuring that a potable quality water can be produced. Flexibility will be of prime importance. Consideration must be given to such questions as the following:

a) Can each item in the treatment facility be bypassed?

b) Can an acceptable water be produced by sedimentation only?

c) Can water be put on the filters without pumping?

d) Can water be filtered without coagulation and sedimentation?

e) To what extent can the capacity for treatment be increased?

Attention must be given to the equipment required to operate the facility. Since explosions begin to cause destruction at only 0.5 psi overpressure, switch gear, chemical feeders, filter control tables, small water supply lines, exposed gate valve stems, etc. become extremely vulnerable and need protection.

Laboratory

Laboratory control of water quality is essential. This is especially true if the normal source of supply is not available and emergency auxiliary supplies must be used. Every effort should be made to insure operation of the laboratory at all times through protection of its location, and sheltering of equipment and required materials. Auxiliary power, water, gas, and communication facilities should be available at all times. Duplicate laboratories at dispersed locations should be available.

Storage

Stored water, isolated at the time of attack may be the only water available in the early recovery period. Every effort should be made to have this quality water available when needed. Storage below ground surface is one of the safest ways to assure survival of the structure. The water should be protected by a well-supported reinforced concrete or steel cover that can resist the effects of overpressure and prevent later contamination from fallout.

To insure the isolation of stored water by preventing inflow of contaminated water and outflow that might be wasted, the disaster operational plan should provide an adequate shelter near the valves that need to be operated and assignment of personnel to perform the necessary operation upon the alert signal.

Distribution System

The response of the above-ground portions of a water distribution system to air blast loading from a nuclear blast can be predicted. Utilizing such information structures can be hardened to withstand a predetermined overpressure. This cannot be done for the below-ground portions of the system, since little is known of the blast and shock force to which piping will be subjected in an area experiencing blast overpressures. Furthermore the structural condition of the piping grid system and the manner in which it will respond to these forces is not known.

Systems deteriorate with use and pipeline failures result even though there is no apparent abrupt increase in loading. Experience does show an increased number of breaks occurring when the loading is abruptly increased such as through water hammer, earthquake shock, and ground freezing. A study of waterworks records indicate that water distribution systems on an average experience 50 pipeline failures per year per 100 miles of pipe. The effect of the blast and shock wave from a nuclear weapon would, it appears, result in many such breaks occurring at the time of blast in addition to the complete destruction of the portions of the system in the vicinity of the crater at "ground zero".

The time to repair the normal breaks that occur throughout the year on a number of systems is shown in Tables VI and VII. For 201 breaks which were observed in steel, cast iron, and asbestos-cement pipe of size 36 inch and smaller the average time for repair is 22 man-hours per break. A maximum for reinforced concrete pipe of 292 hours has not been included in the above average, however.

Assuming that the sections of system having severe damage will be isolated for later recovery and that only that portion that has light to moderate damage will be recovered in the early post-attack period, and assuming there will be 1000 pipeline failures of the character that would have normally occurred within a year's operation per million consumers, a total of 22,000 man-hours would be required to affect repairs under normal working conditions. To this must be added the shut-off time and time for returning the system to service (estimated to be 2000 hours), giving a total of 24,000 man hours or 3000 man days.

Utilizing 48 men and the equipment for eight leak repair crews shown in Table VIII, (the men and equipment now available) a period of 60 eight-hour work days would be required to accomplish repairs and return of pipelines to service under normal working conditions. Much greater time will be required under post-attack conditions (debris, fallout, transportation, lack of experienced personnel, etc.). However, makeshift repairs requiring less time are possible and should be planned.

If a greater number of men are available the equipment may be used for a longer period of the 24-hour day. With three eight-hour shifts of 48 men each, a total elapsed period of 20 days would be required to accomplish the recovery. The normal personnel complement utilizing equipment available in the larger water utilities appears to be capable of no better schedule than this. It is very evident that there may be extensive service areas that cannot be recovered in time to meet the need and water will have to be delivered by tank truck or other bulk delivery during the early recovery.

TABLE VI - MAN-HOURS TO REPAIR WATER MAINS OF VARIOUS MATERIALS

Material	4-Inch	6-Inch	8-Inch	12-Inch	16-Inch	18-Inch	20-Inch	24-Inch	30-Inch	36-Inch
Steel	8	10	16	11	13	-	9	25	12.5	33
Cast Iron	12	21	33	13	131	10.5	18	30	107	107
Asbestos-Cement	24	49	30	112	-	-	-	-	-	-
Weighted Ave for all	11	19	26	30	31	-	13.6	30	28	72

TABLE VII - MAN-HOURS FOR REPAIR OF VARIOUS SIZE WATER MAINS

Size	No. of Repairs	Total Man Hours	Ave. Time/Repair
4in to 8in	87	1679	19 man hours
12in to 18in	49	1029	21
20in to 30in	54	1278	24
36in	11	432	39
All Sizes	201	4418	22

TABLE VIII - WATER UTILITY EQUIPMENT

(Available pre-attack per one million population served)

Type of Equipment	No. of Units
Truck, Van, $1\frac{1}{2}$ to $2\frac{1}{2}$ ton. With tools and equipment for: Service Crews, Pipeline Constr. Crews, Gate Crews, Leak Repair Crews, Regulator and Automatic Valve Maintenance Crews, Pump Repair Crews	25
Truck (service man, pump or system operator), Pickup w/radio, tools, gate keys	30
Truck (electrician), 1 to 2 ton, elec. repair tools	6
Truck, (welding crew), $1\frac{1}{2}$ to 2 ton, welding equipment and tools	8
Trucks, Heavy Duty, 5 to 10 ton, specialized equipment	20
Automobiles - passenger w/radio	50
Backhoe, various sizes	5
Loader, various sizes	15
Tractors, including dozers, various sizes	10
Compressors, various sizes, mobile	20
Generators, various sizes, mobile	10
Pumps, centrifugal, portable, gasoline-driven, various sizes	10
Pumps, (ditch pumps), gasoline-driven, various sizes	30

Note: The water utility will have specialized units of equipment in addition to those listed above. Shop, warehouse, and engineering equipment not listed.

Records and Inventories

Normal procedures assure adequate records, maps, plans, and stock inventories at specific places in the organizational set-up. Consumer accounts, personnel records, legal documents, and other information basically related to administration are usually found only at the business office. Loss of such records during an attack could be serious. Duplicate records located in widely separated locations is advisable.

Equipment and material for recovery is essential. Although each utility is expected to maintain materials, parts and supplies to satisfy the normal 30-day requirements, an emergency situation would require much greater stockpiling. Equipment that might be obtained from contractors, building companies, trucking companies, etc. should be known. This inventory should include both heavy equipment and such items as portable pumping and lighting equipment and air compressor units likely to be needed in making emergency repairs.

Mutual Aid and Joint Ventures

The importance of mutual aid and joint venture agreements as a part of advanced preparation cannot be over-emphasized. Such agreements anticipate the need and provide the type of assistance necessary in an emergency. They make available any of the resources of like or related utilities in time of need. They provide many ways in which assistance can be obtained. One recognized form of assistance is interconnection between water systems. Other resources which can be made available are experienced and skilled personnel, equipment, supplies, and materials.

For mutual aid to be effective, utilities over a wide area should be included in the cooperative agreement. The area of cooperation should be large enough to insure that some assistance will be available even in an extremely widespread and destructive attack. Key personnel should be informed of the basic features of each system and know where plans and operating data are stored. By these agreements, inventorying and stockpiling procedures can be developed. Legal barriers to transferring equipment and problems that might arise from use of personnel and the crossing of state and county lines can be eliminated.

RADIATION PROTECTION

Although the protection of facilities and personnel from blast effects is essential, the need for the protection of personnel from radiation is even greater. Attack levels of 5,000 to 20,000 megatons on this country which may be possible in the near future could produce fallout* that would cover a large portion of the U.S. with fallout levels equivalent to 500 R/hr at 1 hr; a relatively large fraction would receive levels of at least 5000 R/hr at H plus 1 hr and a significant fraction would receive fallout levels of 50,000 R/hr at H plus 1. These latter in the downwind vicinity of hardened missile sites the former values common in the eastern states.

Whereas the effects of blast and shock and thermal radiation are of short duration, radiation from fallout may be dangerously effective for days after the blast. The movement of personnel from shelters to perform essential work must be controlled. This concept of not being able to rush out on the job and make the necessary repairs is contrary to current practice and personnel must be re-trained to act accordingly. Radiation intensity, total exposure dose, accumulated dose, dose rate and stay time must be thoroughly understood and respected by every employee.

Command personnel must make decisions as to whether an operation is essential enough to risk losing the services of workers for later recovery and restoration; whether through decontamination and natural decay radiation is reduced to an acceptable level for controlled-time operations; whether the accumulated dose that workmen have is sufficiently below the limit that another assignment can be given. They must determine the optimum allocation of exposure dose of their available personnel.

Personnel must be protected from radiation in shelters so that a minimum dose will be received while in them and some additional dose can be accepted while doing an essential job. The importance of a high protection factor is indicated in Table IX which shows the minimum protection factor required to prevent the four-day exposure dose from exceeding 200 roentgens under various radiation intensities. The importance of the protection factor in relation to the injury produced by exposure to radiation is indicated in Table X.

Prior to instituting recovery and repair actions at a waterworks facility, a determination of the character and extent of radioactive fallout contamination must be made so that the necessary precautions may be taken. Control of entry time, time of stay, shielding and distance of separation from fallout material is required. The primary hazard from early fallout comes from direct external exposure to gamma radiation.

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* When the term "fallout" is used in this report it refers to those particles which reach the earth within 24 hours after a nuclear explosion. (1)

TABLE IX - RADIATION EXPOSURE DOSE

Unsheltered Personnel and Shelter Protection Factor

for Survival

Radiation intensity at (H + 1) (r/hr)	Approximate 4-day Exposure dose unsheltered personnel	Minimum Protection factor for survival in shelters**	Area of U.S.* Involved, %
50	140	1	50
50-100	140-290	1-2	13
100-300	290-870	2-5	17
300-500	870-1450	5-8	5
500-1000	1450-2900	8-15	5
1000-3000	2900-3700	15-44	8
3000	8700		2
			100%

* Based on "The Probable Fallout Threat Over the Continental United States", by Tec-Ops in which a 4080 MT (2720 fission megatons) attack on both military and industrial targets was assumed.

** Required to reduce the 4-day dose to 200 roentgens or less.

TABLE X

Predicted Relationship Between Dose in Roentgens and Injury (2)

Brief external exposure (Received in a period of a few seconds to 4 days)	Probable condition of Personnel: Medical Care Required	Able to Work	Probable Mortality rate during emergency
12-50 r	No	Yes	0
50-200 r	No	Yes	less than 5%
200-450 r	Yes	No	less than 50%
450-600 r	Yes	No	more than 50%
More than 600 r	Yes	No	100%

Table based on Table 6.4 of Report No. 29 of NCRP

One technique for keeping the personnel hazard at an acceptable level is to allow time for natural decay of the contaminant to a safe level. However the urgency of conserving stored water or restoring certain critical facilities may not permit time for this to occur. Judgment must be exercised in the application of protective measures and in controlling entry time and stay time within established guide lines. Where early repairs are necessary in areas having a high radiation level, the best decision will be to make only the most urgent repairs and defer the less urgently needed repairs a sufficient time for radioactive decay to reduce the hazard.

Accumulated dose records must be maintained for each employee. The total exposure dose can be measured by means of a pocket ion-chamber called a dosimeter. The accumulated radiation dose received is the total of the dose received inside the shelter as well as that while outside the shelter.

Dose which workmen will receive may be estimated using the curves presented in Figures 1, 2, and 3. (1)

Figure 1 presents the relationship of the decrease of dose rate (decay) with time for fallout. In this figure the ratio of the approximate exposure rate (in r/hr) at any time after the explosion to a convenient reference, called the "unit-time reference dose rate"*, is plotted against time (t) in hours. This curve is based on the $t^{-1.2}$ relationship. Although the $t^{-1.2}$ rate of decay represents a reasonable average, exponents throughout the range of -0.9 to -2.0 have been observed. The decay curve may be used in the planning phases and as a guide line following an attack but should be checked as soon as possible after fallout deposition to determine its applicability.

The curves in Figures 2 and 3 can be used to determine accumulated dose and the dose received during various stay times. These curves are based on the $t^{-1.2}$ decay curve of Figure 1. If it is determined that the actual decay curve is significantly different from the curve presented in Figure 1, then the information obtained from Figures 2 and 3 must be considered in light of this difference.

Figure 2 can be used for determining the total dose received from fallout at various times after explosion in terms of the unit-time reference dose rate. To illustrate the use of this figure, suppose that an individual becomes exposed to radiation from fallout at 2-1/2 hours after the explosion. What is the total dose received by (H + 24) if the dose rate is measured at that time and found to be 10 r/hr? The first step is to determine the unit-time reference dose rate. Using Figure 1 and the measured dose rate at (H + 24) of 10 r/hr., the unit-time reference dose rate is found to be 500 r/hr. Next

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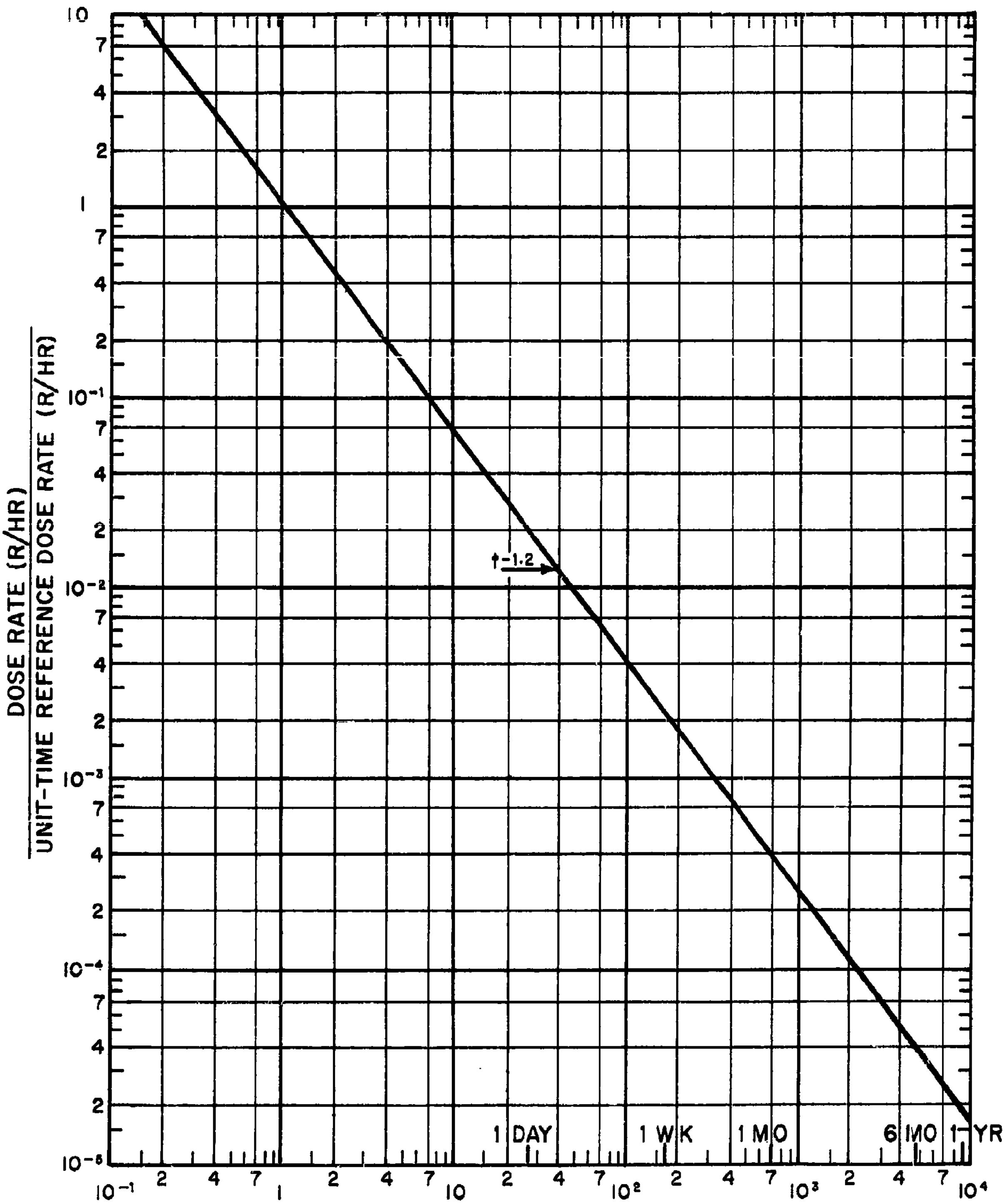
* Also often called the "standard intensity", i.e., dose rate at one hour after the explosion (H + 1).

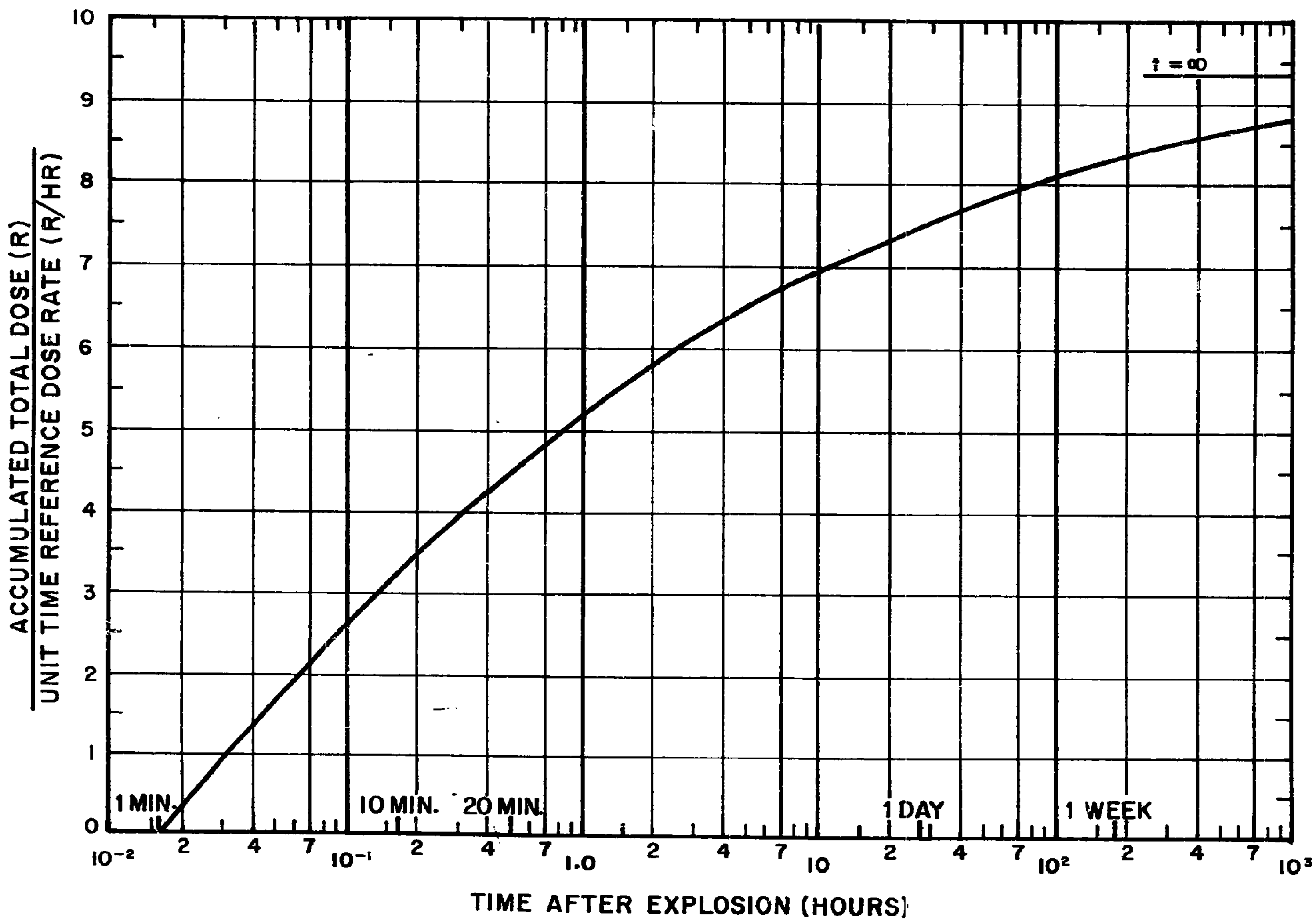
FIGURE 1

DECAY CURVE FOR EARLY FALLOUT



(See ENW-1962)

CURVE FOR DETERMINING ACCUMULATED DOSE

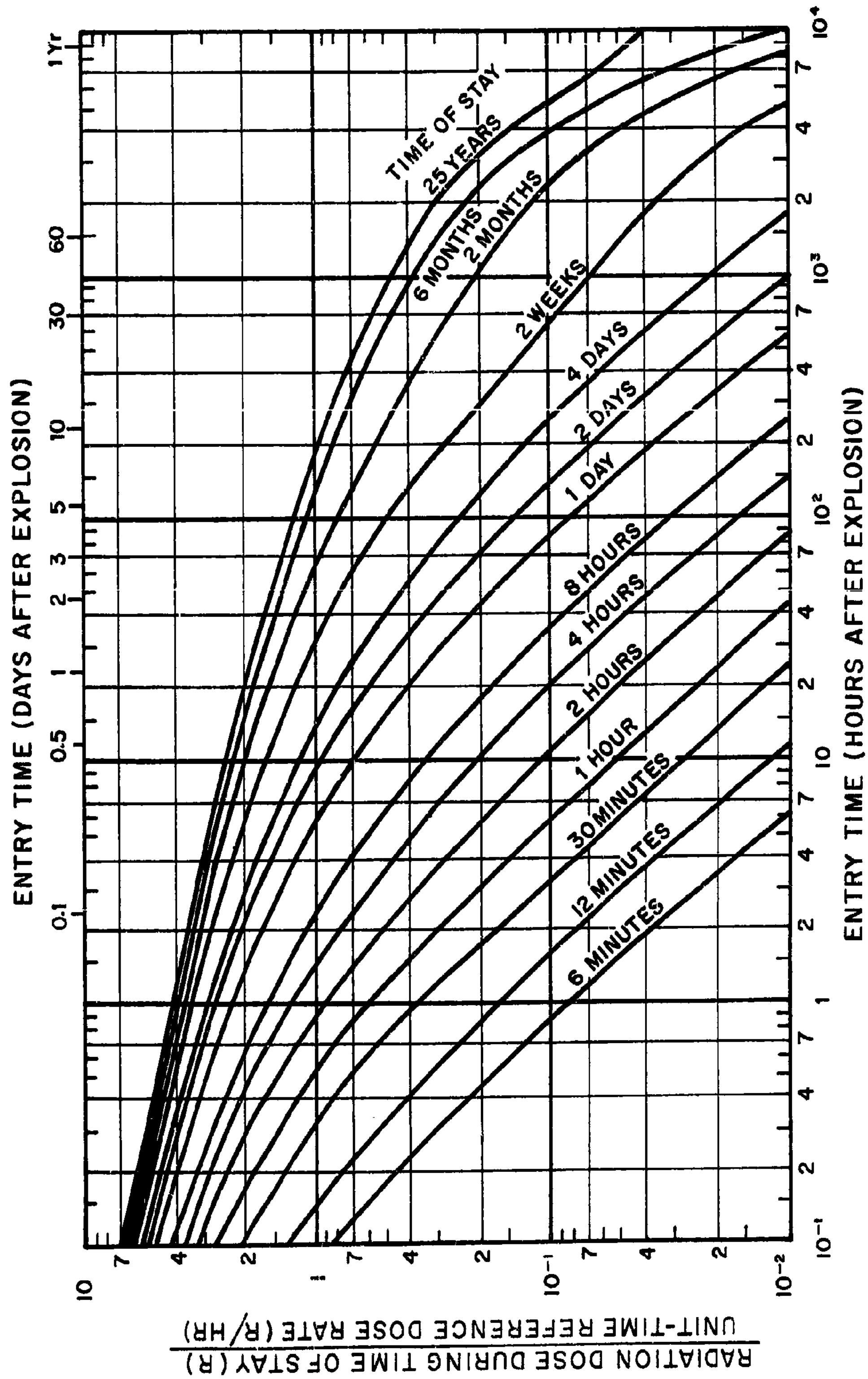


(See ENW-1962)

FIGURE 2

FIGURE 3

CHART FOR DETERMINING DOSE RECEIVED DURING STAY TIME



(See ENW-1962)

from Figure 2 it is found that

$$\frac{\text{Dose received between 2.5 and 24 hours after explosion}}{\text{Unit-time reference dose rate}} = 7.5 - 6.0 = 1.5\text{r}.$$

The total accumulated dose received in the 21-1/2 hours of exposure is therefore 750 r. As can be seen from Table IX this would be a lethal dose, however, one sheltered in an area having a protection factor of 100 would receive only 7.5 r during the 21-1/2-hour period.

The total dose received during the first 24 hours after a nuclear detonation may be estimated by multiplying the unit-time reference dose rate by a factor of 1.5. The actual factor may range from 0.4 for a distant point to 2.6 for a point near the detonation (3).

From Figure 3, the total radiation dose received from fallout during any specified stay in a contaminated area can be estimated if the dose rate at some definite time after the explosion is known. The chart may also be employed to determine the time when a particular operation may be started in a contaminated area in order that a certain total radiation dose will not be exceeded. Suppose, for example, that the unit-time reference dose rate has been determined to be 1000 r/hr and the maximum dose a worker can take considering his accumulated dose is 50 roentgen. The multiplying factor is 0.05. If there is a repair job that will require four hours to complete then using Figure 3 it is seen that the worker must wait until 38 hours after the explosion (H + 38) before beginning the repair job. However, if four men are available and by working together they can complete the same job in one hour, then, as can be seen from Figure 3, the job could be started 10 hours after the explosion (H + 10) with each of the men receiving not more than a 50 roentgen dose.

With a graph such as Figure 3 the decision can be made as to when to begin certain repairs or operational actions by making use of the following information:

a. Radiation intensity at any given time after the explosion.

b. Length of time required to perform function. (Table XI)

c. Travel time.

d. Total number of men available.

e. Accumulated radiation dose already received by each.

Only through such calculations and the subsequent precautions can essential operations be accomplished at the earliest time possible within safe limits and the services of personnel continue to be available for the later tasks of utility recovery.

TABLE -XI - TIME REQUIREMENTS FOR EMERGENCY OPERATION OF WATERWORKS FACILITIES

Type Facility	Operation	No. of Men (Typical)	Time Required - Minutes: Normal Conditions* Min.	Normal Max.	Normal Ave.	Emerg. Conditions** Min.	Emerg. Max.	Emerg. Ave.	Equipment
Deep well plant (electric)	Startup (each unit)	1	1	15	5	60	180	120	Emergency Lights, Tools
	Shutdown " "	1	1	3	1	60	180	120	Emergency Lights, Tools
	Maintenance & Inspection (each unit)	1	1	5	3	60	300	120	Emergency Lights, Tools
Booster plant (electric)	Startup (each unit)	1	1	5	3	60	180	120	Emergency Lights, Tools
	Shutdown " "	1	1	1	1	60	180	120	Emergency Lights, Tools
	Maintenance & Inspection (each unit)	1	1	5	3	60	180	120	Emergency Lights, Tools
Booster Pumping Plant	Hookup portable generator or portable gasoline-powered pump unit (connections available).	3	60	240	120	240	480	360	Emergency Lights, Tools
Reservoir Outlet	Isolation of reservoir	2	10	60	30	120	240	180	Emergency Lights, Tools
Regular Cl_2 Station	Startup (each unit)	1	5	15	10	60	180	120	Gas Mask, Emergency Lights, Tools
Standby Cl_2 Station	Startup (each unit)	2	15	120	60	120	240	180	Gas Mask, Emergency Lights, Tools
	Shutdown " "	1	1	5	2	60	120	90	Gas Mask, Emergency Lights, Tools
	Maintenance & Inspection (each unit)	1	1	3	2	60	120	90	Gas Mask, Emergency Lights, Tools
	Cl_2 Cyl chge 1 ton	2	10	60	20	120	240	180	Gas Mask, Emergency Lights, Tools
	Cl_2 Cyl chge 150#	1	5	15	10	120	180	150	Gas Mask, Emergency Lights, Tools
Distribution System	Open/close valves less than 24", manual oper.	2	1	10	5	60	180	120	Gate key - Lights
	Open/close valves 24" and over, power oper.	2	5	30	20	60	240	180	Gate truck with compr. air motor, or elec. motor - Lights
	Regulator-activate standby units (each unit)	2	15	45	30	60	240	120	Gate key, gages - Lights
	Close or shut 3" to 12" serv. conn.	2	1	10	5	60	180	120	Gate key - Lights
	Repair leak 12" main, (using repair clamp or sleeve. Incl. shutdown time)	6	2(hrs)	20(hrs)	5(hrs)	3(hrs)	30(hrs)	10(hrs)	Repair truck, Compressor & Tools, Excavation equipment - Lights
	Repair major leak (24" pipe or less)	10	3 "	25 "	10 "	4 "	30 "	15 "	As above.
	Disinfect 4" to 24" main, (per 1000')	3	4 "	8 "	6 "	4 "	16 "	12 "	Mobile Cl_2 unit, test equipment, Gate truck equipment - Lights

* Time requirements for typical operations. (Based on experienced operators performing essential operations. Travel time not included.)

** Time requirements under emergency conditions (fallout, debris, panic, limited communications).

Tables XII, XIII, and XIV can be used in the determination of when to assign men to recovery operations. Table XII illustrates the importance of an adequate shelter area. The dose received inside a shelter having a protection factor of 50 or more is small after the first day. Accordingly, beginning the second day the daily accumulated dose may be estimated solely on the basis of time spent outside the shelter for the given unit-time reference dose rate. As indicated in this table, the time spent outside the shelter during the first day could be as much as one hour if there is a high shelter protection factor. Tables XII and XIII both indicate the importance of shelter during the early hours following attack. If the maximum four-day dose of 200 r is not to be exceeded, personnel must remain sheltered for most of the first day. After that the time which may be spent outside rapidly increases. Hence any action that can be delayed until the second day or later will provide greater assurance of accomplishment through lower exposure doses to crews.

With the protection factor known for the given shelter area the total accumulated dose can be determined for various times of stay outside the shelter in different levels of radiation, i. e., different unit-time reference dose rates -- r/hr (3000, 1000, 500, etc.). As can be seen from Table XIII a man who spends one hour outside the shelter the first day beginning at H + 12 and remains inside through the second day would have accumulated approximately 69 r while another man who stays inside the shelter during the first day could remain outside for two hours the second day and accumulate no greater dose. Depending upon the urgency of the needed action and the time required to perform it, such a table will indicate the number of men to be dispatched and/or their exposure time allowance.

Table XIV may be employed to determine the allowable time of stay in a contaminated area before a specified total dose of 50 r is received when the time of entry and the radiation intensity (at H + 1) is known.

The National Committee on Radiation Protection and Measurements in their Report No. 29 have developed the Equivalent Residual Dose (ERD) concept (2). By definition, ERD is the accumulated dose corrected for such body recovery as has occurred at a specific time. This concept assumes that 10% of the injury attributed to the dose is irreparable and that the body repairs the remaining 90% at the rate of 2.5% per day beginning four days after the start of the exposure. This recovery, therefore has the effect of canceling part of the accumulated dose. In the reconstruction and restoration phase after a nuclear attack, decisions concerning radiation exposure to personnel should be based on the consideration of the ERD concept. ERD is not an accepted exposure control policy for the population and may be modified in light of recent radiation biology data.

Other Personnel Protective Measures. Where early fallout has occurred and personnel are required to leave shelters to perform essential work, maximum protection against exposure or contact with the radioactive

TABLE XII

PERIODS OF EXPOSURE WHICH RESULT IN A DAILY DOSE NOT EXCEEDING 50 r FOR A GIVEN UNIT-TIME REFERENCE DOSE RATE WITH VARIOUS SHELTER PROTECTION FACTORS

Unit-Time Reference Dose (H + 1) r/hr			1000		
Shelter Protection Factor	10	50	100	250	1000
1st DAY (H + 1 to H + 24)					
Total unprotected exposure dose-2360r[a]					
Time spent outside shelter beginning at H + 12 (hr-min)	0-00	0-05	0-30	0-50	1-00
Dose received outside shelter (r)	-	4	23	40	44
Dose received inside shelter (r)	236	46	23	9	2
Total dose received during 1st day (r)	236	50	46	49	46
2nd DAY (H +24 to H + 48)					
Total unprotected exposure dose - 330 r					
Time spent outside shelter beginning at H +24 (hr-min)	0[b]	2-00	2-15	2-15	2-15
Dose received outside shelter (r)	-	43	47	47	47
Dose received inside shelter (r)	33	6	3	1	1
Total dose received during 2nd day (r)	33	49	50	48	47
Total accumulated dose (r) - 2 days	269	99	96	97	93
3rd DAY (H +48 to H + 72)					
Total unprotected exposure dose - 190r					
Time spent outside shelter beginning at H +48 (hr-min)	0[b]	5-00	5-30	5-30	5-30
Dose received outside shelter (r)	-	45	48	48	48
Dose received inside shelter (r)	19	4	2	1	1
Total dose received during 3rd day (r)	19	49	50	49	48
Total accumulated dose (r) - 3 days	288	148	146	146	141
4th DAY (H + 72 to H +96)					
Total unprotected exposure dose - 110r					
Time spent outside shelter beginning at H + 72 (hr-min)	0[b]	8-00	8-00	8-00	8-00
Dose received outside shelter (r)	-	48	48	48	48
Dose received inside shelter (r)	11	2	1	1	1
Total dose received during 4th day (r)	11	50	49	48	48
Total accumulated dose (r) - 4 days	299	198	195	194	189

(a) Based on the assumption that fallout is complete at H + 1 and that no dose is received prior to H + 1.

(b) The 4-day limit of 200r exceeded during the first day because of insufficient shelter protection.

TABLE XIII

DOSAGE RESULTING FROM VARIOUS PERIODS OF EXPOSURE FOR A GIVEN UNIT-TIME REFERENCE DOSE RATE AND SHELTER PROTECTION FACTOR

Unit-Time Reference Dose Rate (H + 1) r/hr			1000		
Shelter Protection Factor			100		
1st DAY (H + 1 to H + 24)					
Total unprotected exposure dose - 2860r[a]					
Time spent outside shelter beginning at H + 12 (hr)	0	1/2	1	2	
Dose received outside shelter (r)	-	23	44	90	
Dose received inside shelter (r)	24	23	22	21	
Total dose received during 1st day	24	46	66	111	
2nd DAY (H + 24 to H + 48)					
Total unprotected exposure dose - 330r					
Time spent outside shelter beginning at H + 24 (hr)	0	1	2	3	4
Dose received outside shelter (r)	0	20	43	63	80
Dose received inside shelter (r)	3	3	3	3	3
Total dose received during 2nd day	3	23	46	66	83
3rd DAY (H + 48 to H +72)					
Total unprotected exposure dose - 190r					
Time spent outside shelter beginning at H + 48 (hr)	1	2	3	4	6
Dose received outside shelter (r)	10	20	30	39	52
Dose received inside shelter (r)	2	2	2	2	2
Total dose received during 3rd day	12	22	32	41	54
4th DAY (H + 72 to H + 96)					
Total unprotected exposure dose - 110r					
Time spent outside shelter beginning at H + 72 (hr)	2	3	4	8	16
Dose received outside shelter (r)	12	18	24	45	70
Dose received inside shelter (r)	1	1	1	1	1
Total dose received during 4th day	13	19	25	46	71

(a) Based on the assumption that fallout is complete at H + 1 and that no dose is received prior to H + 1.

TABLE XIV

ALLOWABLE STAY-TIME IN AREA CONTAMINATED BY FALLOUT FROM A NUCLEAR EXPLOSION

(Based on Time Required to Accumulate 50r)

Radiation Intensity at H + 1 r/hr	Entry Time Into Area in Hours After Explosion													
	1	2	3	4	6	8	12	18	24	36	48	60	72	96
	Time Limit in Hours and Minutes to Accumulate 50r After Entry													
10,000	0:00	0:00	0:00	0:01	0:02	0:03	0:05	0:10	0:15	0:20	0:30	0:40	0:50	1:00
5,000	0:00	0:01	0:02	0:03	0:05	0:07	0:10	0:20	0:30	0:40	1:00	1:30	1:40	2:10
3,000	0:01	0:02	0:04	0:05	0:08	0:10	0:15	0:35	0:50	1:10	1:40	2:20	2:50	3:40
1,000	0:03	0:08	0:10	0:15	0:30	0:45	1:10	1:40	2:30	3:30	5:30	7:00	8:30	11:00
500	0:06	0:12	0:20	0:30	0:50	1:10	1:40	3:30	5:00	7:00	12:00	14:00	17:00	22:00
300	0:10	0:20	0:40	0:50	1:20	1:50	2:50	5:30	8:30	12:00	17:00	24:00	28:00	36:00
100	0:40	1:40	3:00	5:00	7:00	10:00	18:00	30:00	45:00	82:00	5 da	7 da	9 da	12 da
50	2:00	6:00	10:00	15:00	27:00	42:00	78:00	6 da	10 da	19 da	31 da	54 da	73 da	120 da

material should be provided. The usual openings in clothes, as around the neck, arms and legs should be closed to prevent fallout particles contacting the skin and causing beta burns. If the fallout is being stirred up by wind or by decontamination crews, gloves, respirator masks, and goggles should be worn. Under some conditions it may be possible to spread a tarpaulin or other type of cover over the fallout-contaminated area during repairs. Thus a worker could stand or kneel on the cover and lay his tools on it, preventing contamination of the tools.

It must be emphasized that the above techniques do not reduce the amount of gamma radiation the worker is exposed to, but only prevent additional injury due to beta burns from the radioactive dust coming in direct contact with the skin.

The increased hazard from infection because of the failure of sanitary safeguards during and following a natural disaster is well known. Persons suffering from exposure to radiation are particularly susceptible to infection. The over-all physical condition of each employee prior to exposure to hazardous agents will have some effect on the extent of the injury suffered. A good immunization program in the advance preparation period is valuable protection against the effects of disease following a disaster.

Decontamination of Facilities. Removal of radioactive fallout from affected facilities including structures, works, equipment and areas should be based on the following considerations:

1. The relative importance of the facility or area, the urgency in returning it to use, and the consequences if restoration is postponed for a period to permit additional decay.

2. The radiation intensity to which workmen will be exposed.

3. The length of time to do the work and achieve the necessary decontamination.

4. The number, availability, and condition of trained personnel and equipment to do the specific job.

5. The existing accumulated radiation dose of the personnel.

6. The feasible decontamination procedures.

Evaluation of these considerations will determine whether a particular facility or area will be decontaminated, and when, how, and by whom.

Decontamination of facilities may be accomplished by treating the surfaces so as to remove or decrease the contamination; by covering with

uncontaminated soil or other material, or by letting the materials stand to allow for natural decay. The most basic principle of decontamination of surfaces is that the contaminant itself is a material which in most instances is deposited on the surface and is not fused or otherwise bound to that surface.

Water is effective in the removal of surface contaminants. It must be recognized that if water is used for decontamination purposes it will become contaminated itself. Consideration must be given, therefore, to the disposal of such water. It should not be discharged into streams where it will affect downstream users or on surfaces where underground sources of water supply will be contaminated.

The facilities and areas which are contaminated should be marked with warning signs posted on all avenues of approach so that recovery personnel may avoid unnecessary exposure. The signs should show time of discovery and the level of contamination.

Surface decontamination methods, classified by type of surface, are listed in Table XV as they appear in the special text on "Industrial Defense" for the course instruction at the Provost Marshal General's School (4). The advantages and disadvantages of each method for various surfaces is indicated.

Many sources of information, including OCD publications, are available on removal of radioactive fallout through various wet and dry methods. Some of these sources are listed in the reference section (5, 6, 7). The methods available include the use of water or other liquids, scrubbing, hosing, vacuum cleaning, push brooms, abrasive treatment, drag-type scrapers, skip loaders, hand shoveling, plowing, and burial.

The roughness of surfaces must be considered in approaching decontamination problems involving fallout. On a flat paved area 50% of all radiation received at a point three feet above the surface, comes from the area beyond a distance of 25 feet and 90% comes from within a radius of 200 feet distance. Thus, it is obvious that to permit operation or repair involves the decontamination of a large area. The roughness of unpaved surfaces partially blocks the radiations coming from fallout material lying in the depressions or behind projections. The amount of radiation received by one working at ground level over a rough unpaved surface may be only one-third as much as that received while working on a paved area contaminated to the same extent.

<u>Equipment and Materials.</u> During the alert period protection from fallout contamination will be accomplished by placement under suitable cover. Tarpaulins, blankets, plastic, etc. can be used thereby reducing decontamination to the easy task of removing the covers.

<u>Source of Supply.</u> Ground water and water held in covered reservoirs will probably remain uncontaminated if structural damage is not too severe. The recovery plan should as far as possible provide for utilization of water

TABLE XV

SURFACE DECONTAMINATION METHODS CLASSIFIED BY TYPE OF SURFACE*

Surface	Method	Advantages	Disadvantages
Paint	Water	Most practical method for gross decontamination from a distance, Contamination reduced by approximately 50 percent.	Protection needed from contaminated spray. Runoff must be controlled. Water under high pressure should not be used on a surface covered with contaminated dust.
	Steam(with detergent if available)	Most practical method for decontaminating large horizontal, vertical, and overhead surfaces. Contamination reduced by approximately 90 percent.	Same as for water.
	Soapless detergents	Where effective, reduces activity to safe level in 1 or 2 applications.	Mild action.
	Complexing agents: Oxalates, carbonates, citrates.	Holds contamination in solution. Contamination on unweathered surfaces reduced by approximately 75 percent in 4 minutes. Easily stored, nontoxic, noncorrosive.	Requires application from 5 to 30 minutes for effectiveness. Has little penetrating power; hence, of small value on weathered surfaces.
	Organic solvents	Quick dissolving action makes solvents useful on vertical and overhead surfaces.	Toxic and flammable. Requires good ventilation and fire precautions.
	Caustics	Minimum contact with contaminated surface. Contamination reduced almost 100 percent.	Applicable only on horizontal surfaces. Personnel hazard. Not to be used on aluminum or magnesium.

TABLE XV (Continued)

Surface	Method	Advantages	Disadvantages
	Abrasion (wet sandblasting)	Complete removal of surface and contamination. Feasible for large-scale operations.	Contaminated sand spread over large area. Method too harsh for many surfaces.
Metal	Water	Contamination reduced by approximately 50 percent.	Same as for painted surfaces.
	Detergents	Removal of oil or grease films.	Do.
	Organic solvents	Stripping of grease.	Do.
	Complexing agents: Oxalates, carbonates, citrates.	Holds contamination in solution.	Difficult to keep in place on any but horizontal surfaces. Limited value on weathered or porous surfaces.
	Inorganic acids	Fast, complete decontamination.	Good ventilation required; acid fumes toxic to personnel. Possibility of excessive corrosion. Acid mixture cannot be safely heated.
	Acid mixtures	Action of weak acid. Reduces contamination of unweathered surfaces.	Same as for inorganic acids.
	Abrasion (buffers, grinders)	Useful for detailed cleaning.	Follow-up procedure required to pick up powdered contamination.
	Abrasion (wet sandblasting)	Same as for painted surfaces.	Same as for painted surfaces.

TABLE XV (Continued)

Surface	Method	Advantages	Disadvantages
Concrete	Abrasion (vacuum blasting)	Direct removal of contaminated dust.	Contamination of equipment.
	Vacuum cleaning	Same as for vacuum blasting on concrete.	Same as for vacuum blasting on concrete.
	Flame cleaning	Only method of trapping contamination on surface.	Slow and painstaking. Fire and airborne radiation hazard is great.
Brick	Same as for concrete.	Same as for concrete.	Same as for concrete.
Asphalt	Abrasion	No direct contact with surface; contamination may be reduced to safe level.	Residual contamination fixed into asphalt. If road is subject to further contamination, may require recovering.
Wood	Flame cleaning	Same as for flame cleaning on concrete.	Same as for flame cleaning on concrete.

* Data from Industrial Defense, The Provost Marshal General's School, U. S. Army

from these facilities during the early recovery period. When contaminated surface water must be used during the early recovery period, conventional water treatment processes will remove suspended radioactive material, but further treatment is required to remove any dissolved contaminants (Figure 4).

The presence of radioactivity in the water supply may be detected by using sensitive laboratory equipment or portable survey meters. The heavier particulate matter may be observed as a fine sand or dust layer on the surface or as turbidity in the water. Various types of laboratory instruments and portable survey meters are available for monitoring radioactive contamination. The portable survey meters can be used, both in disaster areas and laboratories, to determine the levels of radiation from fallout on dry surfaces or from materials in the water.

Some portable survey meters are suitable, with certain modifications, for measuring radioactivity in water in the presence of a high level of background activity (8). For example, the beta-gamma survey meter with the detachable probe can be used by wrapping the probe in Pliofilm (or Saran wrap) and immersing it in at least two feet of water. Sensitivity by this method is reported to be very high and interference from adjacent contaminated surfaces minimal. The ionization chamber high-gamma field detector could also be used in this manner with some simple modifications. In addition, the sensitivity of an electroscope is such that under emergency conditions one may be used to determine whether the radioactivity concentration in a sample is greater than the maximum permissible concentration.

The procedures discussed above are direct methods for determining radioactivity. Indirect methods are also available for detecting and estimating the concentration of radioactivity in water subjected to early fallout (1, 5). These methods are not as accurate as direct measurement but may be useful under early post-attack circumstances. Two methods for relating the fallout radiation intensity of the surrounding land area to the concentration of radioactivity in the waters of a reservoir are given below.

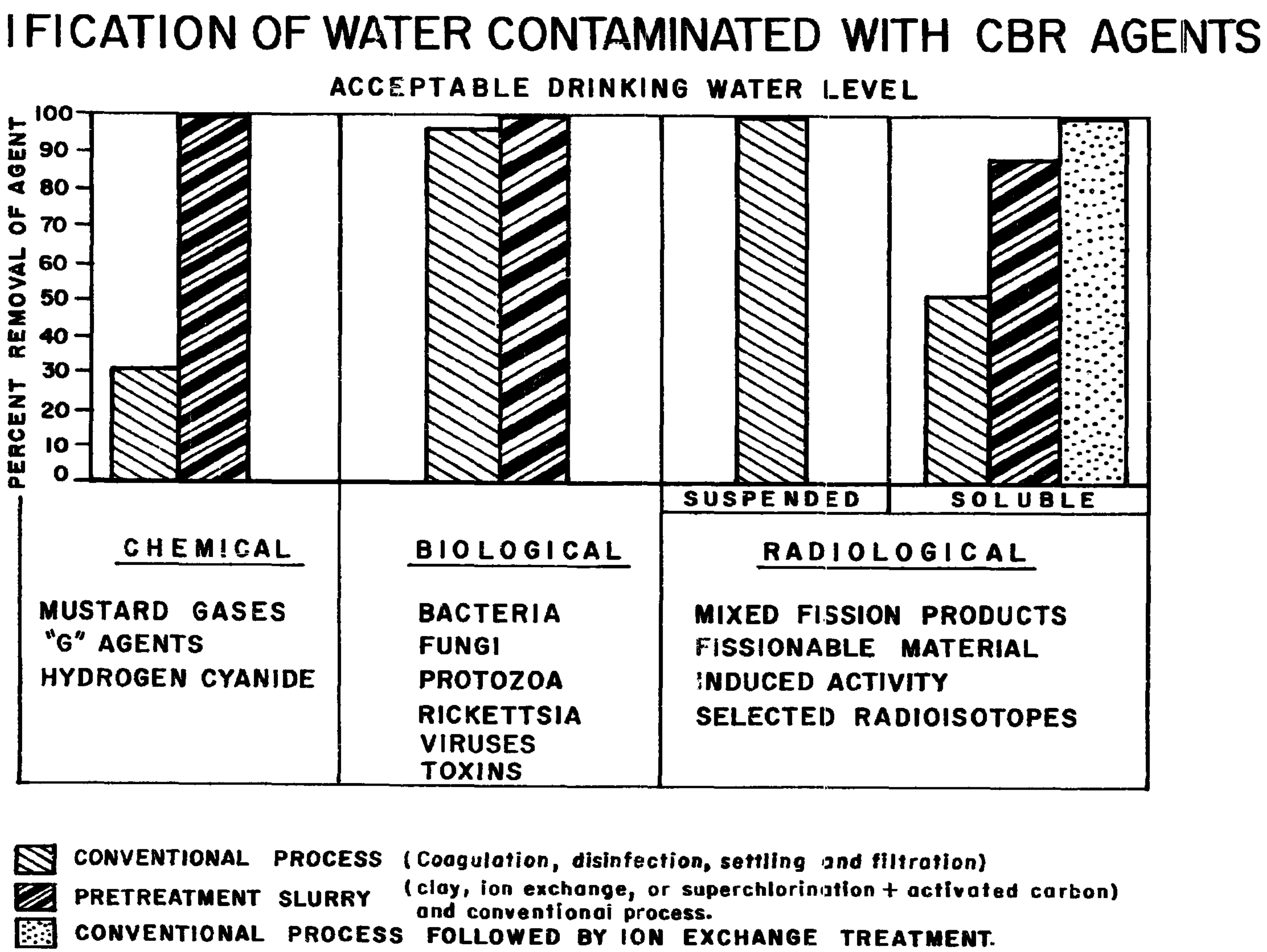
1. The radioactivity dispersed in the waters of an open reservoir may be estimated from the fallout radiation intensity on surrounding land areas by means of the following series of assumptions.

    a) The land area has a shielding factor due to surface irregularities of 0.7.

    b) The detection instrument reads 25 percent low because of its directional response and shielding by the operator.

    c) The gamma ray energy of the fallout is 0.6 million electron volts (Mev). For this energy the radiation intensity three feet above an ideal plane is 4.6 r/hr for a fallout density of one megacurie per square mile (1).

FIGURE 4



* Data from the Corps of Engineers, ERDL, Fort Belvoir, Virginia

Chart by W.J.Lacy

d) The fallout is uniformly mixed throughout the body of water.

By appropriately combining the factors implied in the above assumptions, the water radioactivity is given by the equation,

$$\text{Water Radioactivity in } \mu c/l = 500 \times \frac{\text{Radiation intensity (r/hr) 3' above surrounding area}}{\text{Average depth of water (ft)}}$$

2. Assuming that fallout particles in the water have the same light scattering characteristics and the same specific gravity as the silica particles used in standard turbidity suspension, the fallout can be measured as an increase in turbidity. It has been observed that for each 0.015 gm/ft^2 of fallout deposition from a land surface detonation* the radiation intensity is one r/hr at H +1. Then by using the assumptions of Method 1 above, the radiation intensity for each mg/l turbidity represents about 1000 μc/l gross radiation activity at (H + 1). The activity at later times would be determined from an assumed or measured decay rate.

Table XVI presents the estimated quantities of turbidity and corresponding radioactivity for various fallout radiation intensities (at H + 1) when there is uniform dispersion throughout various depths of water. Table XVI also provides a means, in the absence of a more accurate radioactivity determination, of estimating radioactivity in water at various periods after the nuclear detonation. As indicated in the table, under the given assumptions, an estimate of the radioactivity concentration can be made by multiplying, for example, the turbidity measurement at 1 day by 10, at 2 days by 5 and at 3 days by 3. The presently accepted tolerance levels of beta-gamma activity in water for the first 30 days following a bomb detonation are**

for 10-day consumption, 90 μc/l;

for 30-day consumption, 30 μc/l.

Such criteria are acceptable only during the first month because subsequently a greater portion of the gross radioactivity will be due to the more hazardous longer-lived fission products (10).

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* For maximum intensities from 50% fission yield megaton range weapon, along the hot line.

** The data and background information for determination of these values is presently being reinvestigated. These values may be revised as information concerning biological effects, fallout characteristics, etc. becomes available.

TABLE XVI
ESTIMATED CONCENTRATION OF TURBIDITY AND RADIOACTIVITY IN STORED WATER BASED ON FALLOUT RADIATION INTENSITIES OF SURROUNDING AREA

Radiation Intensity Above Land Surface	Average Depth of Water	Uniformly Dispersed, No Decay		With 90% Removal by Sedimentation, Radioactive Decay Follows the $t^{-1.2}$ Curve*					
		Turbidity mg/l	Radioactivity μc/l	Turbidity mg/l	Radioactivity μc/l				
r/hr at H +1	feet		at H +1	After H +24	1 Day H +24	2 Days H+48	3 Days H +72	10 Days H +240	30 Days H +720
5,000	10	250	250,000	25	500	250	150	35	10
	20	125	125,000	12.5	250	125	75	18	5
	50	50	50,000	5	100	50	30	7	2
3,000	10	150	150,000	15	300	150	90	21	6
	20	75	75,000	7.5	150	75	45	10	3
	50	30	30,000	3	60	30	18	4	1
1,000	10	50	50,000	5	100	50	30	7	2
	20	25	25,000	2.5	50	25	15	4	1
	50	10	10,000	1	20	10	6	1	0.4
500	10	25	25,000	2.5	50	25	15	4	1
	20	12.5	12,500	1	25	12	8	2	0.5
	50	5	5,000	0.5	10	5	3	0.7	0.2
150	10	7.5	7,500	0.8	15	8	4	1	0.3
	20	4	4,000	0.4	8	4	2	0.5	0.2
	50	1.5	1,500	0.2	3	2	1	0.2	0.06
15	10	0.8	750	0.08	1.5	0.8	0.4	0.1	0.03
	20	0.4	400	0.04	0.8	0.4	0.2	0.05	0.015
	50	0.2	150	0.02	0.3	0.2	0.09	0.02	0.006

*Assumptions: (1) Fallout of 0.015 grams/Ft^2/r/hr at (H + 1)
(2) That 90% of the Fallout will Settle Within 24 hours (9)
(3) That the Remaining 10% is Uniformly Dispersed
(4) That Decay Follows the $t^{-1.2}$ Curve and is the Only Factor Acting to Reduce the Radioactivity Concentration.

Figures 5 and 6 can be used to determine the time required for water in a reservoir to reach, respectively, 90 and 30 $\mu c/l$ for various water depths and fallout radiation intensities at H + 1.

The curves in Figure 7 give an indication of the time required to reach the radioactivity concentration of 0.30 $\mu c/l$ in the water for a fallout radiation intensity of 1000, 500, 300, and 100 r/hr (at H + 1) on the surrounding area.

Table XVI and Figures 5, 6, and 7 are based on stored water in which there is no dilution with other water of a different radiation intensity. If there is such dilution it must be taken into consideration.

POST-ATTACK OPERATION

The operation of water supply systems that have experienced the effects of nuclear weapons - radioactive fallout, thermal radiation, blast and shock resulting in structural damage - will differ from that of the pre-attack period. The need for water will also differ from that of the pre-attack period. The waterworks management will have to determine what the post-attack water needs are, the facilities that can be utilized, and the most effective way to resume operation in the available time.

The location of water need as well as the quantity of water can be determined through joint effort with other civil defense disciplines. The fire control personnel will know what the needs are for fire suppression. The decontamination units will know where and in what amounts water is needed for decontamination. The public health units will know the need for sanitary use. The water utility through advance inventorying of their users will know the water users that are considered critical in time of disaster. Other Civil Defense units will know the areas where there are survivors that will need water when their in-shelter supply is exhausted. With this information the water utility can direct the post-attack operation and recovery program accordingly.

The steps which should be taken by the water utility during the trans-attack period are the following:

1) Activate the water utility Civil Defense disaster organization and establish liaison with other Civil Defense units.

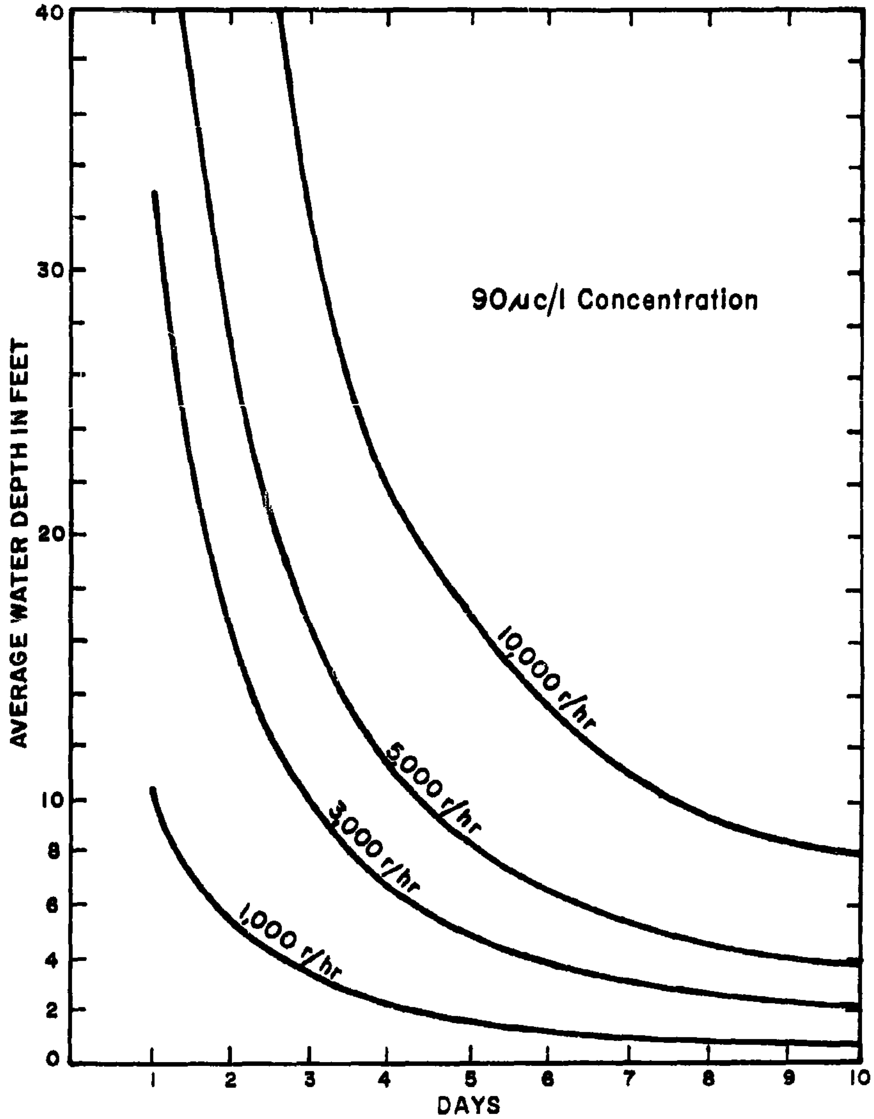
2) Initiate measures for the conservative use of the surviving water supply.

3) Determine the need for water in the post-attack period - location, amount, quality time-phased.

4) Determine the condition of the waterworks facilities and system.

FIGURE 5

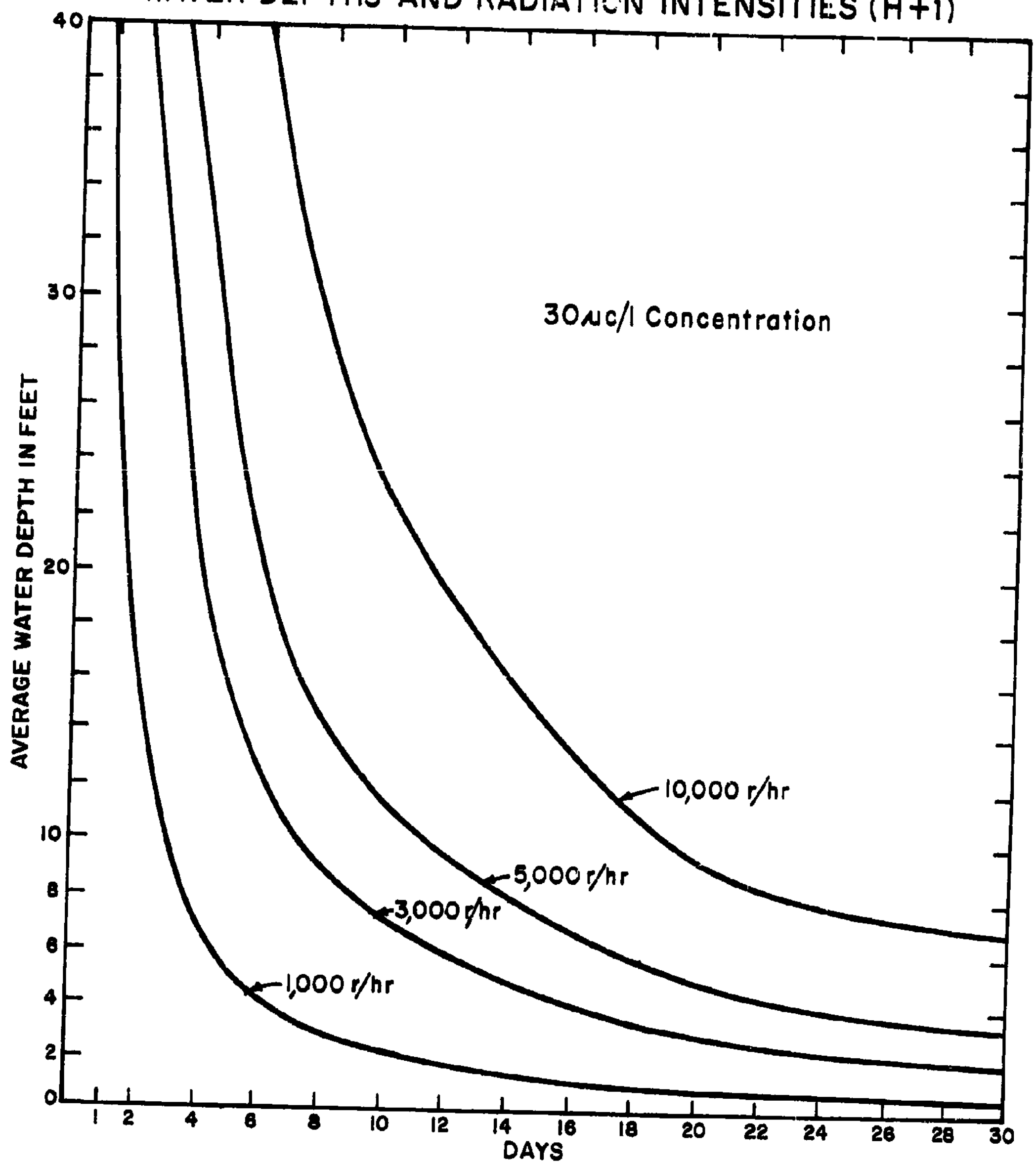
TIME REQUIRED TO REACH 90$\mu c/l$ FOR VARIOUS WATER DEPTHS AND RADIATION INTENSITIES (H+1)



Assumptions:
(1) 90% of the fallout will settle within 24 hours
(2) The remaining 10% is uniformly dispersed
(3) Radioactive decay follows the $t^{-1.2}$ curve and is the only factor acting to reduce the radioactivity concentration.

FIGURE 6

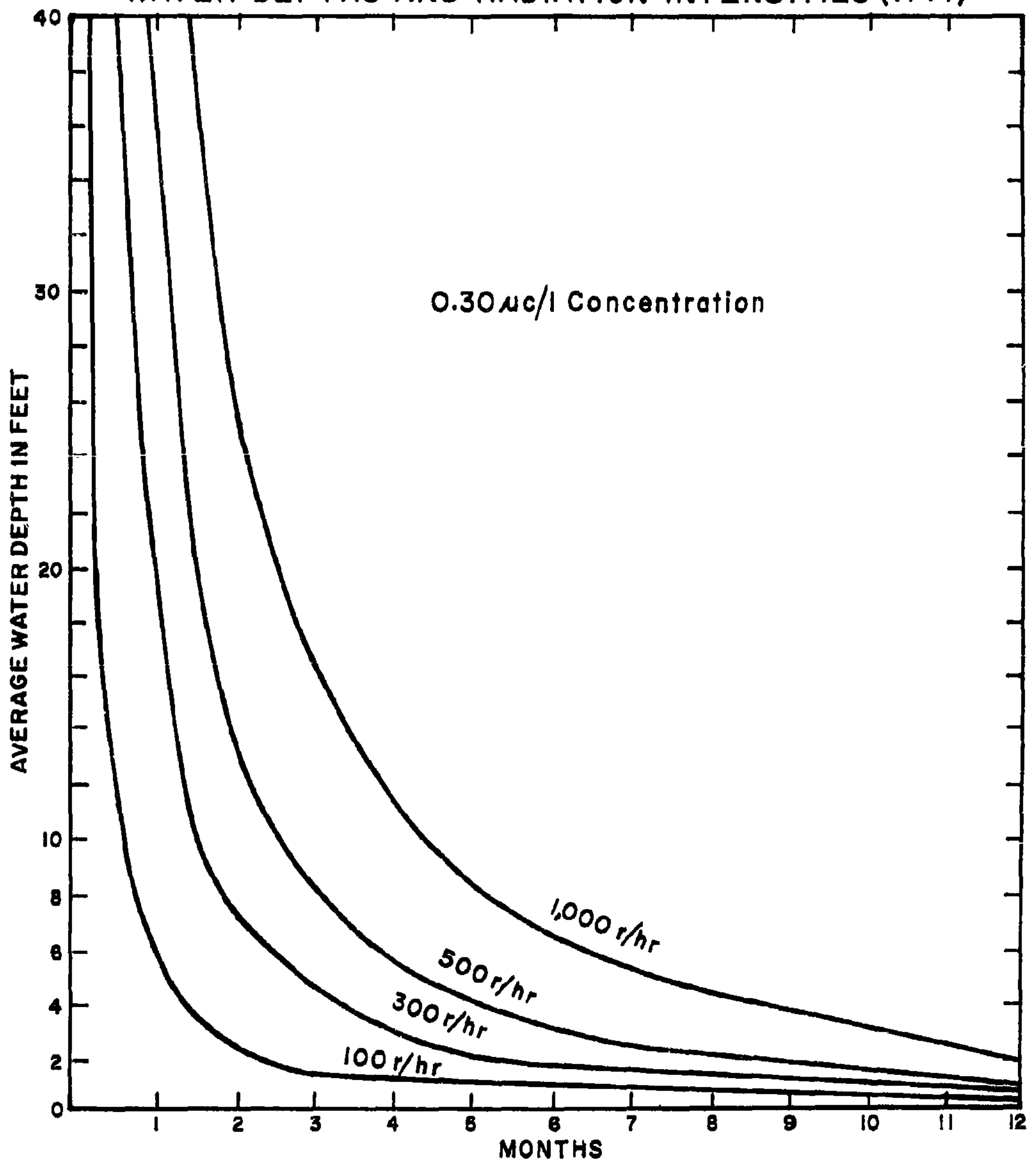
TIME REQUIRED TO REACH 30 $\mu c/l$ FOR VARIOUS WATER DEPTHS AND RADIATION INTENSITIES (H+1)



Assumptions:
(1) 90% of the fallout will settle within 24 hours
(2) The remaining 10% is uniformly dispersed
(3) Radioactive decay follows the $t^{-1.2}$ curve and is the only factor acting to reduce the radioactivity concentration.

FIGURE 7

TIME REQUIRED TO REACH 0.30μc/l FOR VARIOUS WATER DEPTHS AND RADIATION INTENSITIES (H+1)



Assumptions:
(1) 90% of the fallout will settle within 24 hours
(2) The remaining 10% is uniformly dispersed
(3) Radioactive decay follows the $t^{-1.2}$ curve and is the only factor acting to reduce the radioactivity concentration.

5) Evaluate the capability of the surviving facilities, systems, and waterworks personnel.

6) Initiate operational plans to utilize the surviving facilities to supply, so far as possible, the essential needs.

7) Determine essential water requirements for which the surviving facilities are not adequate and time-phase these needs.

8) Determine available methods to supply the supplemental water needs, including repair and restoration of selected damaged facilities, use of alternate sources through interconnection and/or auxiliary emergency construction, improvised methods such as hauling and evacuation of survivors.

9) Initiate supplemental operation and water system restoration.

Operation and Recovery Problem

The operation and recovery problem can be divided into three classes dependent upon how the utility area is affected by the nuclear weapons explosion phenomena (blast and shock, initial radiation, thermal radiation and nuclear radiation from fallout). These are as follows:

Class I) The area receives only worldwide fallout and is otherwise unaffected. The immediate post-attack operations of a water utility in this area is no different from normal operations. Later when utilities that have experienced damage are recovering this utility may, however, render assistance and may supply water for survivors from such other areas.

Class II) The area receives early radioactive fallout resulting in contamination of exposed surface waters. The sheltering of waterworks personnel then results in waterworks facilities going unmanned for some period.

Class III) The area experiences structural damage from blast and thermal radiation and also radioactive fallout.

Operation and Recovery Countermeasures

Class I Area - An area which experiences no direct effect will have no need for recovery countermeasures. The utility will in its operations, however, need to conserve equipment, material,and supplies because of the difficulty with which they may be replenished and, furthermore, to be in a position to assist waterworks that have experienced more severe damage.

Class II Area - In an area which receives early fallout there will be a need for protection of personnel to keep radiation exposures within

acceptable limits. The level of radioactivity in the water supplied for potable use will also have to be considered. Countermeasures for the contamination of the water supply include the use of ground water supplies that are less likely to be contaminated, the holding of surface waters for a time sufficient that settling and radioactive decay reduce the contamination to tolerable levels, the withdrawal of reservoir water from selected depth containing the least contamination, the use of chemicals in storage facilities to increase the removal of radioactivity, decontamination treatment in the utility plants providing sedimentation and filtration, and/or other improvised treatment.

The use of dual water supplies - one for potable use and a more highly contaminated supply for other purposes - is a countermeasure that may be used. However, its success will depend to a large extent upon making the acceptable potable water more readily available than the non-potable supply and in keeping the population informed of the hazard to them if they use the non-potable supply.

Class III Area - In an area affected to some extent by all the explosion phenomena of nuclear weapons, the countermeasures for the protection of waterworks personnel and the water quality considerations will in part be similar in character to those in a Class II area. However, because of blast and shock damage, as well as physical injury of waterworks personnel, the application of countermeasures and recovery of water supply will require greater effort and take a longer time to accomplish. Debris clearance and decontamination will further add to the recovery time. The utility will need to call up auxiliary personnel in numbers commensurate with the personnel lost in the attack and the increased needs resulting from damage to the system.

Applicable countermeasures for the blast and shock effects are the following:

1) The conservative use of surviving water facilities, equipment, and material.

2) The use of water from stored supplies which have survived the attack.

3) The isolation of the undamaged facilities from the damaged facilities and the continued use of these undamaged facilities.

4) The controlled use of water whereby only minimum essential needs are satisfied.

5) The use of alternate and/or auxiliary sources of supply and waterworks facilities through temporary construction and improvised operations.

6) The repair and restoration of damaged facilities.

The countermeasures to be applied for recovery of waterworks in the post-attack period will be based on a consideration of the water needs, the condition of the surviving facilities, and the availability of equipment, supplies, and knowledgeable personnel. Countermeasures that may be applicable to insure the operation and recovery of the various facilities of a water supply system are given in the following outline.

A) PERSONNEL

1) Initial Nuclear Radiation

Effect - Ionizing radiation penetrates the body to injure and kill personnel exposed at time of attack.

Countermeasure - Shelter (shield) personnel with considerable thickness of high density material at time of attack.

2) Thermal Radiation

Effect - Burns the skin to injure and kill personnel exposed at time of attack (of secondary effect are flame burns from fires set by the attack).

Countermeasure - Shelter (shield) personnel with solid opaque material at time of attack.

3) Radioactive Fallout

Effect - Ionizing radiation associated with particulate matter injures and kills personnel exposed (not adequately sheltered) during time fallout is arriving and for extended period thereafter.

Countermeasure - Shelter personnel from time fallout starts arriving until natural decay reduces it to tolerable level; decontaminate personnel by removal and disposal of particulate matter where exposure to fallout has occurred; monitor levels of radiation, determine individual exposure dose, and control entry time and stay time within tolerable limits; decontaminate work areas and equipment by removal and disposal of particulate matter.

4) Blast and Shock

Effect - Injury and death of personnel exposed to blast overpressure; injurious effects also from displacement and impact (including the impact of the body on a solid object and vice versa).

Countermeasure - Shelter (shield) personnel from the pressure wave; shield personnel from displaced objects.

B) SUPPLY

Ground Water Source (Wells)

1) Initial Nuclear Radiation

Effect - No effect on quantity or quality.

2) Thermal Radiation

Effect - No effect on quantity or quality.

3) Fallout Radiation

Effect - No appreciable effect on quantity or quality.

4) Blast and Shock

Effect - The well itself being below ground surface is afforded a high degree of protection. However, it may experience some damage to an extent depending on the distance to and character of explosions. There may be contamination as a result of damage to nearby structures such as sewers or there may be flooding by surface water flows if within flood zone.

Countermeasure - Water analysis after attack and treatment as indicated necessary; extension of well casing above flood levels that may occur as a result of warfare (considering ruptured waterlines, failure of water storage facilities and increased stream flows).

Surface Water Source (Impounded Supply)

1) Initial Nuclear Radiation

Effect - No direct effect on water supply.

2) Thermal Radiation

Effect - Brush and forest fires resulting in watershed runoff containing increased amounts of suspended materials; toxic materials from burned plants on the watershed area.

Countermeasure - Hold water in impoundment storage for solids to settle; minimize surface flow into intake impoundment by manipulation of upstream check dams; by-pass water containing debris; treat water in impoundment by improvised methods to flocculate and settle suspended material; select level from which water is withdrawn to deliver water of better quality; increase solids removal in the normal treatment process by adjusting chemical feed, increasing flow-through time, or using auxiliary treatment.

3) Radioactive Fallout

Effect - Particulate matter will drop onto water surface and on tributary watershed and result in radioactive contamination of the water.

Countermeasure - Hold water in impoundment to allow time for radioactive decay and for suspended material to settle; other measures as listed in 2) above for removal of suspended material.

4) Blast and Shock

Effect - Supply may be lost because of damage and failure of impoundment facilities. (See "Structures"); water quality may be impaired because of damage to structures on the watershed resulting in discharge or spilling of hazardous materials, i.e. sewage, toxic chemicals, etc. from land installations, toxic chemicals from damaged boats and barges. Increased water turbidity due to wind and wave action.

Countermeasure - Use of alternate source of supply such as ground water basin or storage in distribution system; by-pass water containing excess amounts of material; emergency improvised water treatment; other measures as listed in 2) above that are appropriate.

Surface Water Source (Direct Stream Diversion)

1) Initial Nuclear Radiation

Effect - No direct effect on water supply.

2) Thermal Radiation

Effect - Brush and forest fires resulting in watershed runoff containing increased amounts of suspended materials; toxic materials from structures destroyed or damaged by fire.

Countermeasure - Flocculation, sedimentation, and filtration as discussed for impounded supply; by-passing of flows during time materials are present in objectionable amount; use of alternate supply.

3) Radioactive Fallout

Effect - Exposed water surface and subsequent watershed runoff contaminated with radioactive material.

Countermeasure - Use of alternate source; by-passing flows containing amounts in excess of predetermined limits, treatment.

4) Blast and Shock

Effect - Supply may be lost because of damage and destruction of intake facilities or because of change in course of stream; other effects as listed for impounded surface supply.

Countermeasure - Utilize alternate intake or alternate supply; appropriate measures listed for impounded supplies.

C) STRUCTURES

1) Initial Nuclear Radiation

Effect - No damaging effect.

2) Thermal Radiation

Effect - Charring or burning of structures made of flammable materials, such as reservoir roofs, wooden poles supporting communication and electrical facilities, and buildings housing well pumps and disinfection equipment; waterworks facilities especially vulnerable to fire when in high fire risk environment (forest area).

Countermeasure - Protect flammable structures with shielding materials, i.e. mound structures, white paint, etc. (waterworks structures are to a great extent fire-resistant); provide for fire control measures; dispersion of units at widely separated locations.

3) Fallout Radiation

Effect - Deposition of fallout and resulting radiation preclude workmen utilizing work areas.

Countermeasure - Providing for unmanned operation; remaining away from structure until radioactivity has decayed sufficiently; decontamination of surfaces by removal of fallout material.

4) Blast and Shock

Effect - Blast wave distortion producing structural damage; loosened objects hurled through the air as destructive missiles; displacement of objects; deposition of damage debris so as to impede movement, decontamination, and access to facilities.

Countermeasure - Abandonment and by-passing of unit; the anchoring of parts that may react as missiles; shielding by such measures as burial or mounding; providing greater structural strength.

D) EQUIPMENT

Communication, Electrical, Chemical Feed, Laboratory, Transportation, Construction, and Maintenance

1) Initial Nuclear Radiation

Effect - No damaging effect.

2) Thermal Radiation

Effect - Igniting of flammable portions of equipment exposed at time of explosion; burning structures and materials in immediate environment of equipment resulting in secondary fire damage to equipment.

Countermeasure - House equipment in fire resistant structures; shield equipment with fire resistant materials; provide measures for fire suppression; locate equipment in low fire risk areas.

3) Fallout Radiation

Effect - No direct effect; precludes repair and manual operation (See "Personnel").

Countermeasure - Shielding from fallout; decontamination (See "Personnel").

4) Blast and Shock

Effect - Missile damage by dislocated objects; debris from superstructure rendering equipment inaccessible; gauges, automatic controls, and oil lines broken; various parts of different stability torn apart; translocation of equipment; structural failure.

Countermeasure - Shield in shock resistant structure (See "Structures"); anchor equipment; increase structural strength of weakest components.

Application of a Recovery Procedure

The principles of post-attack waterworks operation discussed previously intthis section can best be illustrated by constructing the sequence of events which might occur in a hypothetical situation. Accordingly in the following paragraphs an imaginary water utility is described, and its operations are followed through an assumed disaster period.

The study of metropolitan waterworks indicated that

1) Utilities are constructed and equipped in accordance with good waterworks standards and are staffed with key personnel trained in recovery operations;

2) Operation and maintenance personnel number approximately 400 men per million water users;

3) Utility service areas vary from approximately 40 square miles per million users to 150 square miles per million users with one to five operating sectors.

The staffing and the equipment available for repair and operation of a community water supply system per one million users are shown in Table XVII and Table VIII respectively.

The recovery procedure is applied to an imaginary water system that is divided into five sectors for operational purposes as follows:

Sector 1 - Surface stream intake with gravity flow to sand filtration plant; high lift pumps discharge to distribution system of Sector 1; balancing in three reservoirs. Low lift pumps deliver water to ground storage in Sectors 4 and 5.

Sector 2 - Surface intake, low lift pumps, sand filtration plant, high lift pumps to distribution system of Sector 2 balanced in four reservoirs and

TABLE XVII - WATERWORKS OPERATION AND MAINTENANCE PERSONNEL

(Available pre-attack per million water users)

Type	Number Per Mil.	Popl. Served
Service or Pipeline Construction Crews 6 men, (Van Truck w/compr.)	20 crews	120 men
Welding Crews, 1 man, (Truck)	8	8
Meter Insp. Crews (service men), 1 & 2 men. (Truck with radio)	22	40
Gate or leak Crews, 2 & 3 men (Truck with radio)	20	50
Regulator Crews (automatic valve crews) 3 men (Truck with radio)	5	15
Pumpers, 1 man, (Truck with radio)	30	30
Treatment Plant Operators (inc. quality control)	1	15
Pump Repair Crews, 3 to 5 men (Truck)	2	8
Electrical Repair Crews, 1 man (Truck with radio)	6	6
Truck Drivers (Heavy-duty trucks, dump trucks, gasoline trucks, etc.)	15	15
Maintenance Shop personnel; machinist, welders, blacksmiths, carpenters, warehousemen, mechanics, etc.	50	50
Const. Equip. Operators	14	14
Supervisory, Records, Communication, and Support Personnel		29
	Total	400

Notes: Each crew with a qualified foreman or lead man.
The number of plant operators will vary greatly depending on the water system and treatment provided.

to distribution system of Sector 3 balanced in three reservoirs.

Sector 3 - Receives water by pressure flow from Sector 2 distribution system through a number of connecting lines and, in addition, develops some relatively small amount of ground water by means of wells pumping directly into distribution system.

Sector 4 - Receives water from Sector 1 system and repumps supply from ground storage to distribution system, balancing flow in four reservoirs. High rise business district in Sector 4 is served by a secondary high pressure river water system for fire control. Fire pumps operate on power from electrical utility or from auxiliary fuel-operated generators at the pumping plant. Plant has been hardened.

Sector 5 - Receives water from Sector 1 by means of transmission line that traverses Sector 4 and enters Sector 5 by river crossing at Avenue A Bridge. Has ground storage and high lift pumps to distribution system balancing in three reservoirs. Some supply also developed by means of wells drawing from ground water basin in eastern portion of Sector 5.

It is assumed that

(1) There are one million water users in the utility service area.

(2) The water supply is developed primarily from the surface stream by means of two widely separated intakes with rapid sand filtration plants at each.

(3) A secondary auxiliary source of utility supply is wells in the service area.

(4) A number of industrial plants in the service area have their own system taking surface stream water for industrial use.

(5) A small amount of ground water is developed by means of wells for individual and industrial use in the community.

(6) The water utility operates from a central administrative headquarters and five sector headquarters.

(7) The organization for emergency operations follows this same organizational pattern - a central headquarters command with five sector command posts.

(8) Each sector has a number of control posts and a number of assembly areas where personnel report, are sheltered, and from which they operate.

(9) Each of the five sectors has equipment and material stockpiled at convenient locations.

(10) The water utility has a Civil Defense disaster organization and operational plan.

(11) The water utility operates on power supplied by the electrical utility serving the community and, in addition, has auxiliary stand-by generating equipment at some of the water system facilities.

(12) The utility has a three-way radio communications system.

(13) The water utility experiences the effects from a surface burst of one or more nuclear weapons.

(14) There is light to moderate structural damage.

(15) Early fallout necessitates decontamination operations and the control of entry time and stay time for waterworks employees up to and including (D + 7) days after attack.

(16) The waterworks personnel are sheltered and 340 (85%) of the 400 pre-attack operation and maintenance employees are available for recovery operations.

(17) Sufficient equipment and supplies are available for survival and recovery operation to proceed with the help of cannibalization and improvisation.

The recovery procedure is time-phased as follows:

I. Time - D day (first 24 hours)

<u>Conditions:</u>

Headquarters ascertains:

1) The water utility command personnel are safe in control headquarters shelter.

2) The headquarters shelter has not suffered damage.

3) Communications to OCD, disaster posts, and water utility control points and assembly areas are operating.

4) The area of the utility has experienced a nuclear weapons strike or near miss.

5) Severe damage has been inflicted to some of the waterworks facilities.

6) Heavy early radioactive fallout is occurring in the area of the water supply system.

7) Water system command post for Sector 5 does not respond to efforts to communicate.

8) Command posts for Sectors 1 to 4 report: No damage to command post shelter; unable to communicate (no response) with a total of 3 control points and 4 assembly areas; various vacancies in the utility disaster organization staff; very little information available on extent and character of damage to waterworks system; Sectors 1 and 2 were successful in isolating quality water storage from system during alert period; Sectors 3 and 4 were not successful in the isolation of quality water; no information from Sector 5.

9) "Quality water" being lost at a rapid rate in Sectors 3 and 4; no information Sector 5.

10) OCD reports power lost in southeast section of metropolitan area (Sectors 4 and 5 of water utility).

11) Sector 4 reports public power off and auxiliary power at main pumping plant not operating.

12) Sector 4 reports emergency power supply maintaining automation.

13) No raw water entering Treatment Plant No. 2 in Sector 2.

14) Fires reported in numerous locations.

Operations:

Command personnel evaluate information they obtain from waterworks personnel and other Civil Defense sources and direct procedure for placing the waterworks Civil Defense recovery plan in operation.

Measures are initiated to activate alternate personnel through lines of succession to fill vacancies in staffing.

Command posts place the emergency administrative operational procedures in effect.

Any period of time before arrival of fallout may permit

a) Placing system on an un-manned operational status.

b) Initial appraisal of facilities by operating personnel sheltered therein taking a quick look.

c) Personnel shifted from poorly sheltered location to better protection.

Equipment in use:

1) Communications equipment

2) Radiation detection equipment

Personnel in action:

1) Command personnel

2) Radiological personnel

3) Engineering personnel

4) Supervisory operating personnel

5) Radiological monitors with equipment

II. Time - (D + 1)

Conditions:

1) The entire nation has suffered what appears to be severe damage to the extent that little if any outside assistance in early recovery operations can be expected.

2) Early fallout is complete; radiological units report levels of radiation with predictions for next 24 hours and indicate very limited probing possible for assessment purposes and for high-priority operations.

3) DOD reports weapons characteristics, location, and size. One bomb inflicted blast damage to area of water supply system; an additional number of bombs resulted in fallout and fires affecting the water supply especially in upstream watershed.

4) Communication is established with alternate command post for Sector 5 of waterworks system.

5) Command personnel positions in all five sectors now filled, operating from alternate posts in many instances.

6) Heavy debris in central portion of water service area and in vicinity of some essential waterworks facilities, especially in Sectors 4 and 5.

7) Fire personnel is requesting information on availability of water at many designated locations.

8) Stockpiles of material, equipment, and supplies in Sectors 1, 2 and 3 have not experienced blast or fire damage.

9) Power outage reported by Sector 1 at river pumps, Treatment Plant No. 1, and at high lift pumps. Also no power to low lift pumps on the transmission line to Sectors 4 and 5.

10) Telemetering equipment in Sectors 1 and 3 not operating.

11) Bad chlorine leak at Treatment Plant No. 1.

12) Two of the four reservoirs in Sector 2 are isolated.

13) Transformer station supplying power at raw water pumps to Treatment Plant No. 2 severely damaged.

14) Superstructures of Treatment Plant No. 2 collapsed. Plant severely damaged. Personnel report shelter is flooding and they are seeking alternate location.

15) Avenue A bridge collapsed, breaking water supply main to Sector 5.

16) Main quality water storage reservoir, Sector 5, ruptured, flooding pumps serving high-level system.

17) Severe fire condition Sector 5.

18) Damage assessment in Sector 4 hindered by heavy deposits of debris.

19) Operating personnel at main pumping plant, Sector 4 control point, have not reported.

20) Severe fire condition in Sector 3.

21) Structural damage to high-rise apartments and fires reported in Sector 1.

22) Stockpile damage reported in Sectors 4 and 5.

Operations:

Shut off chlorine tank at Treatment Plant No. 1.

Probing operations for very limited stay time to assess damage to critical facilities.

Laboratory personnel initiate monitoring of water supply.

A determination of probable extent of damage to each waterworks facility is made from the weapons characteristics reported by DOD. Through the use of map overlays and the information developed by pre-attack vulnerability and damage criteria studies information is developed and supplied to control point personnel to assist them in planning.

Equipment in use:

Laboratory equipment

Continued use of D-day equipment

Gas Masks

Radiological dosimeters

Personnel in action:

Selected operating personnel

Laboratory personnel

Continued use of personnel possessing skills listed under D-day.

Summary Report:

Near-miss strike of nuclear bomb has inflicted severe damage to water utility. Treatment Plant No. 2 is severely damaged and supply from this source is interrupted. Power outage at

Treatment Plant No. 1; no major damage apparent. Some wells in Sector 3 continue to operate while all other wells have been rendered inoperable either because of direct damage or interruption in power supply.

Severe damage inflicted to Sector 4 main pumping plant and Sector 5 pumping plant, neither of which are operating.

Attention is directed to the need for conservative use of in-shelter stored water.

III. Time - (D + 2)

Conditions:

1) OCD reports additional water supply will be needed for survivors about D + 7.

2) Hospitals (A, B and C; Sectors 1, 2 and 5) report heavy draft on their emergency water facilities.

3) Radiation level now permits sufficient longer stay time for initial assessment if personnel are sheltered in vicinity of operation (heavy debris in some sectors hampers movement, and some "remote" facilities still inaccessible).

4) Large portions of Sectors 4 and 5 probably damaged beyond recovery.

5) Sector 5 entirely without a water supply; high level reservoirs drained.

6) Fire department requests emergency pumping equipment to supply river water to Sector 5.

7) Radiological monitor reports main pumping plant, Sector 4, severely damaged.

8) Sectors 4 and 5 report no public utility power available.

9) Fire department reports their high-pressure system operating under emergency power in Sector 4.

10) Fires in Sector 1 reported to be burning out.

11) Treatment plant in Sector 1 returned to operation.

12) Considerable loss of water through services to buildings in Sectors 1 and 3.

Operations:

Request decontamination units to decontaminate designated emergency work areas.

Shut off transmission main at Avenue A bridge.

Isolate stored quality water in Sectors 3 and 4.

Restart electrical equipment at Treatment Plant No. 1.

Dispatch crew to ascertain condition of high-level pumping plant in Sector 5.

Fire department informed water available in Sector 1 and in limited quantity in Sectors 2 and 3.

Plans made to dispatch mobile water treatment units to Hospital A in Sector 4 with supply taken from high-pressure system, and to Hospitals B and C, in Sectors 2 and 5, taking supplies from emergency sources.

Plan shut off of sections of Sectors 4 and 5 considered beyond recovery.

Plans made to dispatch emergency pumping units to Avenue A bridge to supply water for firefighting in Sector 5.

Plan early damage assessment to water facilities in Sector 5.

Plan with debris removal units to provide access to main pumping plant, Sector 4.

Plan early assessment of damage to Treatment Plant No. 2, Sector 2.

Plan early assessment of damage to raw water pumps on river intake above Plant No. 2.

Plan to supply water from Sector 1 system to Sector 5 system.

Equipment in use:

Trucks for gate, electrician, and pump crews

Trucks for transporting materials and welding equipment

Mobile water treatment units

Emergency pumping units with power

Continued use of (D + 1) equipment

Increased numbers of dosimeters.

Personnel in action:

Increased numbers of radiological monitors with equipment.

Gate crews

Pump crews

Electricians

Mobile treatment plant operators

Welders

Pipeline construction crews

Continued use of personnel possessing skills listed under D +1.

Summary Report:

Effects of the attack are generally known and recovery planning is started. The radioactive decay has lowered radiation levels permitting damage assessment in greater detail. Sectors 4 and 5 are in the worst condition. The transmission main to Sector 5 was destroyed and wells in the sector are not operating, leaving that sector without water. The main pumping plant in Sector 4 is out of operation and severely damaged. Planning is directed primarily to improving conditions in these sectors. Sector 5 can be furnished some water from Treatment Plant No. 1 by installation of temporary transmission line, crossing river on railroad trestle.

IV. Time - (D + 4)

Conditions:

1) Doors and windows of all facilities in Sector 1 blown in.

2) No significant structural damage to three reservoirs in Sector 1.

3) No damage to river intake Treatment Plant No. 2, Sector 2, but pumping station superstructure collapsed. Pumps and transformers badly damaged. Early recovery not possible.

4) Treatment Plant No. 2 structure and equipment badly damaged. Superstructure collapsed. Early recovery not possible.

5) Some damage to intake and discharge piping to high-lift pumping station at Plant No. 2. Reinforced concrete building shows only spalling and cracks. Pumps show little evidence of damage.

6) One reservoir ruptured and one, not isolated, is undamaged but drained in Sector 2.

7) Six of the utility wells in Sector 3 are operating but the other six are not.

8) Unfiltered and unchlorinated water being pumped to system from Treatment Plant No. 1, Sector 1. No treatment because of lack of manual operation.

9) It is now estimated severe structural damage of 10% has been experienced.

10) 85% of the pre-attack operations and maintenance staff is now available.

11) Debris hinders assessment and recovery operations in some areas especially in Sectors 4 and 5.

12) Fires are bad in sections of upstream watershed.

13) Sector 5 without potable water except that at mobile purification unit at Hospital C.

14) Reservoir in Sector 5 damaged beyond recovery.

15) Removal of superstructure debris necessary at high-level pumping station, Sector 5, to permit detailed damage assessment.

16) Apparently there is severe damage to switch gear, pumps, motors, piping, and appurtenances in high-level pumping stations, Sector 5.

17) Estimate 100 fire hydrants damaged, 30 main breaks and numerous breaks on domestic and fire services in Sector 5.

18) OCD reports industrial plants No. 1 and No. 2, Sector 5, have stream intakes for industrial water supply.

19) Power company reports power will be available in the industrial district of Sector 5 not later than (D + 5).

20) All wells in Sector 5 are badly damaged and early recovery not possible.

21) Assessment and evaluation indicates that breaks in Avenue A transmission line in Sector 5 can be repaired or bypassed.

22) Debris removal and decontamination crews report access to main pumping plant, Sector 4, will be possible (D + 5).

23) On inspection, pumping plant, Sector 4, found damaged by debris.

24) High level transmission line around Plant No. 2 can be recovered to bypass plant.

Operations:

Mobile water treatment units placed in operation at Hospital A, B and C.

Emergency pumping units at Avenue A bridge placed in operation.

Dispatch mobile treatment unit to Avenue A emergency pumping plant.

Plan recovery of Avenue A transmission line in Sector 5; to be supplied by emergency pumping at Avenue A bridge and emergency connections from industrial plants No. 1 and No. 2.

Dispatch engineering crew to industrial plants No. 1 and No. 2 to assess damage to private industrial water supply and to plan with plant personnel to recover for utility use.

Plan for recovery of main pumping plant, Sector 4.

Plan for recovery of low-level transmission from Treatment Plant No. 1 to main pumping station Sector 4.

Plan recovery of Avenue A transmission line south from bridge.

Plan for recovery of high-level transmission line to bypass Plant No. 2.

Plan for recovery of river pumping plant ahead of Plant No. 2.

Plan for recovery of the six wells not operating in Sector 3.

Plan for connecting distribution system of Sector 1 to high-level system, Sector 5, through emergency pumping and temporary transmission line.

Plan for hauling water from Sector 1 to locations OCD designates in Sector 5.

Plan for hauling water from quality water storage in Sector 4 to various distribution points in the sector.

Equipment in use:

Debris removal equipment

Emergency pumping equipment

Mobile water treatment equipment

Radiological decontamination equipment

Tank trucks for hauling water

Additional trucks with specialized tools and equipment

Continued use of equipment listed under (D + 2).

Personnel in action:

Additional personnel as listed in (D + 2).

Summary Report:

Evaluation of system indicates the major portion of the water supply will have to come from Filter Plant No. 1 and the twelve wells in Sector 3. Water for Sector 5 will be supplied by emergency measures, through use of mobile purification units and transportation from outside areas pending construction of temporary supply

line from Sector 1. Sector 4 will be supplied potable water from quality stored water isolated in the sector. Recovery operations will be devoted largely to insuring an adequate supply for the survivors in Sectors 4 and 5 when they start emerging from shelters. Valving off damaged portions of system is being emphasized while methods for recovery of transmission mains are being carried out.

V. Time - (D + 7)

<u>Conditions:</u>

1) Fire department reports their water needs are slackening in Sector 5.

2) Repair crews report temporary repair of breaks in Avenue A transmission line in Sector 5.

3) Engineering reports surface water supplies at industrial plants No. 1 and No. 2 now delivering non-potable water into south end of Avenue A transmission line, Sector 5.

4) Emergency pumping to Avenue A line at bridge (north end) continues.

5) Heavy water loss from transmission line Avenue A, Sector 5, from lateral lines.

6) Potable quality water in Sector 5 now available from mobile treatment plants at Hospital C and at emergency pumping plant at Avenue A bridge.

7) OCD report sheltered survivors now leaving shelters in need of potable water, Sector 5.

8) Present supply potable water in Sector 5 grossly inadequate.

9) Engineering reports water from distribution system, Sector 1, can be fed into high-level system, Sector 5, with emergency low-lift pump and 10,000 feet of pipe by (D +14).

10) Alum coagulant feeding and chlorination reestablished at Treatment Plant No. 1.

11) All stored water in Sector 4 depleted except that isolated in early post-attack.

12) Fire department reports their water needs in Sector 4 slackening and they can now supply some non-potable water to the utility system.

13) Fire suppression and loss of water in Sector 3 has depleted all stored water except that isolated from the system in early post-attack period.

14) OCD reports minimal potable water needs are 150,000 gallons per day for the 150,000 survivors now leaving public shelters in Sector 5.

15) Home shelter survivors leaving shelters in quest of water, all sectors.

Operations:

Valve crews dispatched to speed up the closure of branch lines from Avenue A transmission main.

Engineering reports high-pressure fire system can be interconnected to supply minimal sanitary water needs in Sector 4 by (D + 16).

Emergency disinfection treatment is being installed to treat water from high-pressure fire system in Sector 4 now distributed through a portion of the utility system.

Continue to valve all leaks in Sectors 1 and 3.

Construction started to put water into high-level system in Sector 5 from Sector 1.

Water-hauling operations initiated for Sector 5 by use of tank cars and usable railroad track from community XYZ.

Engineering reports all major leaks in Sector 1 will be controlled by (D + 14).

Water supply from Treatment Plant No. 1 has been increased three-fold through in-plant changes and use of auxiliary pumping facilities.

Softening treatment ~~not~~ resumed in Plant No. 1.

Plan to install emergency pumps with auxiliary power at Treatment Plant No. 2 river intake to supply water to high lift pumps at Plant No. 2.

Plan to recover high lift pumps at Plant No. 2.

Plan to recover high-level transmission line around Plant No. 2.

Plan emergency disinfection of river water by-passing Plant No. 2.

Program for disinfecting distribution system for quality water started.

Equipment in use:

Excavation equipment

Debris-removal equipment

Decontamination equipment

Radiation detection equipment

Survey meters

Emergency pumping equipment

Mobile water treatment equipment

Portable disinfection equipment

Laboratory equipment

Trucks with specialized tools and equipment

Welding equipment

Mobile generators, compressors

Automobiles

Tank trucks

Tank cars

Locomotives

Personnel in action:

All classes shown in Table XVII.

Laboratory Personnel

Summary Report:

Recovery operations are progressing. Sector 5 presents the greatest problem. Water hauling has had to be initiated in Sector 5. Non-potable water from industrial plants in Sector 5 and from fire system in Sector 4 now available. Emergency chlorination will be added to these supplies in the next few days.

Survivors in shelters have been cautioned that when they leave the shelter they should not take water from any source unless a "Safe for Drinking" sign is posted there.

VI. Time - (D + 14)

Conditions:

Sector 1:

1) Source facilities, stream intake, and Pumping Plant No. 1 operating three times normal flow.

2) Water Treatment Plant No. 1 operating at three times normal flow. Water softening treatment not applied.

3) Water loss from distribution system now controlled; all portions of area now being supplied quality water.

4) Water from Sector 1 being hauled to Sector 5.

5) Connection to take water from Sector 1 into high-level system of Sector 5 nearing completion.

6) Raw water shows some contamination with radioactive materials; treated water is within acceptable 30 days' use level.

7) Normally assigned operation and maintenance staff, assisted by those of the previously arranged auxiliary personnel that are now available, can carry out operation and recovery of this sector.

8) Treatment plant chemicals are available for only 30 days' needs at present rate with the revised treatment not practiced.

9) Estimated there are 100 main line breaks in distribution system; many more water service connections to buildings broken.

Sector 2:

1) Treatment Plant No. 2 severely damaged and initial recovery of no part expected before (D + 90).

2) Power service restored to raw water pumping plant serving T§eatment Plant No. 2.

3) Raw water pumps badly damaged in river plant. 10% capacity can be restored by (D + 30).

4) Operation expected to be re-established by (D + 45) through use of pumps from damaged industrial water supply system.

5) Limited emergency supply will be available from Sector 1 by (D +16).

6) Relatively little damage to water distribution system within Sector 2 (estimated 50 main line breaks), many water services broken.

7) Recovery of high-level transmission line around Plant No. 2 progressing. Expected completion date (D + 30).

8) Quality water available from mobile treatment plant at Hospital B, quality water stored during the alert and early emergency period, and hauled water from Sector 1.

Sector 3:

1) Fires are controlled.

2) Little structural damage to system. (Estimated 25 main line breaks; few water service lines broken).

3) System operating on controlled supply from stored quality water.

4) Six utility wells now back in operation.

5) 300 recorded private wells now being used by individuals.

6) Connections now being made to supply public system by use of treated industrial well supplies.

7) Water restrictions and controlled use to be in effect pending completion of recovery of supply from Sector 2.

Sector 4:

1) Power has been restored to all parts of Sector 4.

2) It will take three months to recover a portion of main pumping plant and six months to recover entire facility.

3) A total of 100 fire hydrants damaged by blast and debris, and water mains damaged at 250 locations.

4) Many service lines damaged.

5) Present quality water supply from Sector 1 and that stored during early emergency period and from mobile treatment unit at Hospital A.

6) Use of non-potable water by means of the high-pressure system continues.

7) Water being hauled from low-level system to people in high-level system service area pending installation of numerous interconnections with pumps to deliver water to high-level system.

8) Additional construction personnel would facilitate recovery.

Sector 5:

1) Distribution system badly damaged. (Estimated 500 main line breaks, many service lines broken).

2) Avenue A transmission line has been recovered and is isolated from much of the damaged distribution system.

3) Emergency poor quality water (disinfected) now being pumped to Avenue A transmission line at north end (Avenue A bridge) and at south end (industrial plants No. 1 and No. 2).

4) Quality water available at mobile treatment plant at Hospital C, at mobile treatment plant at Avenue A bridge pumping plant, at mobile treatment plant at industrial plants No. 1 and No. 2, and from Sector 1 piped to high-level system and hauled to the remainder of Sector 5.

5) Survivors in Sector 5 are urged to obtain their needs from Sector 1 so far as possible.

6) Will take three months to place temporary supply line across river at Avenue A.

7) Will take one month to recover high-level pumping plant.

8) Temporary transmission line being laid on railroad bridge to supplement supply to Sector 5.

VII. Time - (D + 14) to (D + 1 yr$\pm$)

Temporary emergency repair and recovery of water supply system continues.

The time required for the repair and early recovery of a water supply system will depend among other considerations upon the workmen, equipment, and materials that are available post-attack, the level of radioactive fallout, and the extent and character of damage. An operational guide, time phased in accordance with the recovery operation reviewed here, for a system supplying one million people is given in Table XVIII to show required manpower for the recovery and restoration assuming light, moderate, and severe damage; and, furthermore, with fallout making necessary decontamination operations and the control of entry time and stay time in work areas up to (Dc+7).

The ability of a water works utility to recover at a sufficient rate to meet minimum needs using the surviving personnel from the 400 pre-attack employees (Table XVII) (augmented with available auxiliary personnel) will depend largely upon how many of the workmen are successfully sheltered during the attack, and the extent of damage. Those essential needs that can not be supplied by the piped community water supply system will have to be supplied by other methods until the system is restored adequately to supply the water.

TABLE XVIII OPERATIONAL GUIDE

EARLY POST-ATTACK RECOVERY AND EMERGENCY RESTORATION OF WATER SUPPLY SYSTEMS EXPERIENCING LIGHT, MODERATE AND SEVERE DAMAGE

Operation	Time Phase (for starting)	Manpower* (man days) Extent of Damage Light	Moderate	Severe
Initial appraisal of attack and effect on water system	D day	1-5	1-5	1-5
Initial assessment of damage to facilities	+ 1	40-80	60-100	100-150
Develop preliminary operations plan (revised as assessment information improves) Conserve quality water in storage (continuation of program of alert period)	+ 2	50-100	75-200	100-300
Detailed assessment of damage and evaluation of system Activate stand-by sources, including poor-quality water for fire control and decontamination. Control water loss through damaged distribution system, reservoirs, and transmission lines.	+ 4	75-200	100-300	150-500
Initiate recovery of sources, treatment, and transmission facilities. Reactive use of stored quality water. Initiate quality water service to critical and high-priority users.	+ 7	1000-2000	1500-3000	2500-4000
Complete detailed plans for restoration of facilities Continue recovery operations to supply 10 to 40 gallons per day per survivor through distribution system.	+ 14 (to 1 yr.)	8,500-17,000	15,000-40,000	25,000-50,000

* Estimated manpower for recovery and emergency restoration of water supply system serving 1 mil. persons. Personnel for operation of system not included.

CHAPTER V

IMPROVISED METHODS AND PROCEDURES FOR SUPPLYING EMERGENCY WATER

The supplying of water to survivors in metropolitan areas that have been subjected to the effects of nuclear warfare is an essential part of the Civil Defense post attack recovery operation. OCD has indicated that shelter supplies should include stored water sufficient for 14 days. The OCD also hopes that essential utilities will remain functional during attack or be able to restore essential operations shortly afterwards.

The extent to which these measures - water storage by the individual and capacity for continuing operation and recovery - result in meeting the essential water needs during and following attack will not be known until an actual attack is experienced. There are no prototypes that can be observed, and pilot studies of a sort which might provide some guidance are not considered feasible. Therefore, the formulation of a preparedness program must be based largely on judgment. Decisions must be made in view of the drastic consequences of an error, and in recognition of the limitations of the various possible alternatives.

Of prime importance in a war-created disaster will be the availability of water in the immediate vicinity of the survivors. Under normal conditions the extensive distribution nets of community water supply systems provide continuous service at numerous points over large areas. In those communities where there is no structural damage to the water supply system the distribution system may continue to function or may experience interruption in operation only during the period in which the workmen are "tied down" in shelters because of radioactive fallout. In this case, the primary consideration may be that of water quality deterioration resulting from the attack. Studies performed by others as a part of OCD's shelter water supply program indicate that a supply of one quart per person per day for a two-week shelter period may be available from elevated and ground storage and the distribution system piping, provided there is no physical damage sustained or fire demand exerted.

For an attack where structural damage does result in an interruption in the operation of some facilities or damage to the distribution system impedes delivery of quality water to survivors through the piping, other sources of supply and means of transportation must be utilized while the community system is being repaired. The advance determination of the potential emergency water requirements and methods for the supplying of such emergency water under post attack conditions will increase the chances of fulfilling the requirements should the need arise.

WATER USE CATEGORIES

Determination of emergency water needs in the advance preparation program must be made on the basis of quantity as well as quality for various categories of use. The use categories considered herein include potable, sanitary, decontamination, fire fighting, industrial, and agricultural water.

Potable water is water intended for drinking and cooking. Conditions following an enemy attack may preclude use of the community water system and it is therefore necessary that individuals maintain a small reserve for essential domestic needs during such periods. The Office of Civil Defense recommends that seven gallons of water per person be provided in fallout shelters (11). When fallout radiation has subsided enough to permit egress, the survivors will have to be provided with potable water at accessible locations.

During a disaster it may be necessary to use any water that is available for survival. The commonly used drinking water quality standards for domestic use cannot be met under all disaster conditions. The primary quality considerations for a potable water under such circumstances will be radioactivity, sewage contamination, and contamination with other highly toxic material. Slightly contaminated water which has been treated with chlorine or other disinfectant may have to be used, with no other measures to assure its purity. Survivors should be kept informed on the condition of water sources and instructed in any necessary precautions. The Health Department will have a major responsibility in determining the acceptability of the available supplies and defining measures which the individual domestic users may use to provide protection. The highest priority on available potable water supplies should be given to hospitals and other medical care facilities.

Sanitary water uses include personal washing, cleansing of living and work areas, and water for flushing where water-carriage sewerage facilities are provided. Sanitary water will be needed throughout the disaster period and especially when survivors start leaving shelters. Decontamination and sanitary waters generally have the same quality requirements. Although it would be desirable that these waters, when distributed through the community system, meet potable standards, this may be impossible to achieve during the emergency. If potable water quality is not maintained, care must be taken in the use to which the water is put and survivors must be given appropriate information.

The Office of Civil Defense has prepared information (12) showing the minimum amount of potable and sanitary water that should be provided by the water utility during disaster. These quantities are summarized in Table XIX. The more adequate supplies should be made available where possible.

Table XIX

Minimum Potable and Sanitary Water Quantity Requirements

Hospitals and other Medical-care Facilities	5-25 gallons/casualty/day
Mass-care Centers and other Welfare Installations	
Lodging and emergency feeding	5-15 gallons/person/day
Lodging centers-drinking, hand and face washing uses only	2 gallons/person/day
Lodging centers with operative flush-toilet facilities - drinking, feeding, and sanitary uses	25 gallons/person/day
Mass-feeding stations - cooking and sanitary uses	3-10 gallons/person/day
Households	
Drinking, cooking, and cleansing	5-15 gallons/person/day
With operative flush-toilet facilities	25 gallons/person/day

Decontamination water is that water used for washing radioactive fall-out from facilities, areas, building, persons, etc.

Fire-fighting water is that water required to suppress fires and to cool debris. This use may impose a need early in the post-attack period for large volumes of water. Quality of fire-fighting water is not important, and any available supply may be used as long as it does not clog piping and pumping equipment. Under conditions of extreme emergency it may be necessary to supply non-potable water for suppression of fire and decontamination through the water distribution system. If this water is distributed in such a way that it might be mistaken for a potable supply, appropriate notification to the survivors should be given. Proper decontamination of the system will be necessary before it can again be used to convey potable water.

Industrial water may be required to sustain or re-establish those industries essential for survival or defense. Through advance preparation inventories the water needs of such industries will be known and can be considered in early recovery planning. The same industrial water use inventories may also reveal sources of water for emergency use in the post-attack period.

Agricultural water is that water used to irrigate crops. The required quantity and to a much lesser extent the quality of agricultural water will depend on the specific type of agriculture involved. Where it is available, this water may prove to be quite important in supplying various needs in addition to the agricultural during recovery.

EMERGENCY WATER ALLOWANCES

General Considerations

Advance preparation for the supplying of water during an emergency should include the consideration of water allowances, rationing, priorities, and time-phasing of estimated water requirements. Critical water users should be inventoried and their quantity and quality requirements determined. After the attack, water is likely to be available only in limited quantities, and should be used on a priority basis with due consideration given to over-all recovery needs. Depending on the use to which it will be put, there will be various quantity and quality requirements. These requirements will change with changing conditions of the period and the water supplier will have to consider such changing conditions in determination of use priority.

Water Allowance Scales

The water allowance scales considered in advance preparation for a particular disaster condition will have to be evaluated at time of emergency in the light of conditions then prevailing. However the establishment of a scale of water allowances will help point up disaster needs and thus be helpful in advance preparation. In addition it will provide guide lines for use in the post-attack period allocation of water to the various users.

The disaster periods used in determining water allowance scales can be designated as survival, early recovery, restoration, and reconstruction. Survival allowances are the minimum quantities necessary for sustaining human life. Early recovery operation allowances are the minimum necessary to provide for high-priority needs during the early disaster recovery period. Such minimum quantities will usually be provided under severe conditions for relatively short periods of time. Restoration operations will take place over a longer period of time and conditions will generally be less severe; water allowances for some uses will begin to approach pre-emergency levels. Reconstruction operations will extend over an appreciable period after the service of essential water has been effected and attention may be directed to rehabilitation of the system.

Appropriate allowances can be established corresponding to criteria associated with each of the above emergency conditions. Table XX following shows estimated water allowances for given potable uses for each emergency period.

Table XX

Estimated Emergency Water Allowance

Water Use Category and Type of Facility or Operation	Water Allowance Unit	Estimated Water Allowance: Scale A Survival	Scale B Early Recovery	Scale C Restoration	Scale D Reconstruction
1. Potable Water					
a. Homes, shelters	gal/cap/day	0.5	0.5-5	5-40	40
b. Hospitals	"	5	15	25-40	40
c. Mass-care	"	3	10	15-25	25

(Water Allowance for other categories to be developed by utility).

Time-Phase of Estimated Water Requirements

In the days following a disaster, progressively increasing quantities of water must be provided to satisfy minimum water needs. Where the community water supply system has been damaged and early radioactive fallout is present, there is little that can be done at the community level to supply water until sufficient time has elapsed for the radioactivity to decay to a level that will permit improvised operations without exposure to lethal doses of radiation. During the early post-attack period, after fallout decay has progressed sufficiently for emergency workers to leave shelters for controlled periods of time, improvised measures such as hauling may be initiated. As the permissible exposure period is extended, additional amounts of water will be needed and efforts to supply water through undamaged portions of the distribution system can be instituted. Early water requirements will be primarily for drinking and for the care of the sick and injured. Later in the disaster period when the further decay of radioactivity permits still greater recovery activity, increased quantities will be needed for decontamination and for the recovery of food processing and other essential industries. Time studies of estimated water requirements can determine the minimum supplies, equipment, manpower, and organization arrangements needed to meet the water requirements by designated post-attack dates. The time-phasing can be prepared assuming time intervals for establishment of water allowance scales. Table XXI demonstrates one method of relating the time-phasing of minimum water allowances to the predetermined water allowance scales as given in Table XX. The date of the attack is referred to here as "D" day.

Table XXI

Estimated Water Allowance Scale Time-Phase

Water Use Category and Type of Facility or Operation	Water Allowance Scales to be used on or before Estimated Indicated Date			
	D Day to D+14	D+15 to D+45	D+45 to D+90	D+90 to D+ 1 yr.
1. Potable Water				
a. Homes	A	B	C	C - D
b. Hospitals	A - B	B - C	C	C - D
c. Mass-Care centers	A	B	B - C	C

(Scale for other categories to be developed by utility).

EMERGENCY SOURCE INVENTORY

One of the first and the most important advance preparation steps for the supplying of emergency water is to locate and inventory potential auxiliary and emergency sources that could be used in the post-attack period. Water supplies for emergency use may be available from surface and ground water sources inside and outside the utility area. Information on availability of water from emergency sources may be obtained from the following organizations.

Local

Water Utilities

Flood Control Agencies

County or City Health Departments

Public Works Departments

Industrial Plants - Commercial Buildings

Electric Utilities

Well Drillers

Waterworks Association members

State

Water Resources Agency

State Health Department

State Geological Survey

Federal

Public Health Service

Army Corps of Engineers

Geological Survey

Bureau of Reclamation

Department of Commerce

Department of Agriculture

A listing of the potential sources should take into account location, capacity, probable potability and safety, the need for treatment, reliability of continued operation during an emergency, means of connection, number of men and their operating skills, estimate of the equipment or supplies likely to be needed, and the means of locating the person or persons responsible for the supplies. A permanent connection with the potential source or means to make a quick temporary connection should be provided in the advance preparation.

IMPROVISED METHODS FOR DISTRIBUTING WATER

General Considerations

After the emergency water sources have been located and inventoried, the utility must consider the methods by which these sources will be used to distribute water under conditions that are likely to exist at time of need. The efforts of utility personnel after they can leave the shelters will be devoted primarily to returning the system to satifactory operation as quickly as possible. During this time it may be necessary to provide water by some improvised method. Delivery of the emergency water may not necessarily be the direct or sole responsibility of the utility. Other agencies may also be involved; this policy decision will have been made in the advance preparation period.

In addition to putting source facilities back into operation, a major problem during the early recovery period will be transporting water to points where it is urgently needed. This can best be done by obtaining emergency water directly from the utility system if it is operative in or near the area of need. The next logical source of water is from other supplies in the distribution area. It may be necessary to use sources that are not normally considered potable and to improve the water quality by improvised treatment. Much can be done through advance preparation in the determination of sources of supply, methods for treatment and distribution, and the training of Civil Defense workers to carry out the operation. Where survivors cannot be supplied with piped water provision will have to be made for the hauling of water to accessible locations or for moving of survivors to areas where they can obtain water. The hauling of enough water to supply even the minimal need for survival of a considerable portion of a large metropolitan population will be difficult to accomplish. At an allowance of one-half gallon per survivor per day, the daily water need for 5000 survivors will be 2500 gallons, and for 500,000 people, a daily need of 250,000 gallons weighing 1000 tons. Therefore efforts of the utility personnel should be devoted to the development of piped distribution from sources of supply near the points of demand.

Water from Utility System

The utility distribution system itself may be the best source of emergency water, especially if efforts to conserve stored water (discussed in Chapter IV) have been successful. Destruction of key facilities - storage, pumping, supply mains - may prevent any sort of normal operation, but any portions of the system found to be operative may be used to serve water to some of the consumers directly. Parts of the system that carry contaminated water should be isolated and the consumers in such areas informed of the situation; they should be advised on taking protective measures. Service might be intermittent and restricted to a few hours per day. It may be necessary to provide water service directly from storage facilities, sources of supply, or from transmission pipelines. Water might be served to the local residents or to water tank trucks from hydrants provided with taps. The use of manifolds with a number of taps will help to step up the rate of delivery of the water where large numbers of people are to be supplied.

The water that may be held in the distribution system piping should be considered in the advance preparation, and measures should be developed for its use, especially where large lines are in the vicinity of shelters and other locations where there may be survivors. Water may be trapped in inverted siphons or low sections of line; it could be made available by tapping the line at the low point, by use of a low lift portable pump, or by dipping through openings in the pipe. Other mains in the distribution system, even those on sloping terrain, might have sections wherein sizeable amounts of water might be trapped. The 9,000 gallons that may be trapped in a 100-

foot-long section of 4-ft diameter line represents a 14-day supply of one quart per day for 2500 people; even the 2500 quarts held in a 100-foot length of 12-inch line would supply 2500 people for one day. Likewise the appreciable volume of water stored in building water tanks, water heaters, and building water piping should be considered in the advance preparation.

Water from Adjacent Sources of Supply

Adjacent sources of supply that are operative could be extremely important in providing a minimal supply during the early emergency period; however, such sources may well be as badly damaged as the utility system itself. Even so, interconnections with adjacent water utilities, whereby water may be delivered in either direction, are highly desirable. The existence of reduced sizes of mains at the fringes of the utility system often decreases the amount of water that may be available through such interconnections. If the flow through the connection is not sufficient under prevailing pressure differential, an auxiliary portable pump may be used (preferably so valved that suction and discharge can be interchanged). Studies should be made in the advance planning to determine the number and size of portable gasoline or diesel engine-driven auxiliary generators and pumping equipment that may be needed for such purposes and their availability in the area.

The use of adjacent industrial, irrigation, or other private supplies presents similar possibilities for the supplying of water during periods of disaster. Water storage on private properties, such as tanks, reservoirs, swimming pools, or cooling towers, may also be available, but its total volume may be only a very small part of that needed. Surface waters that are not normally used for domestic purposes, such as lakes, rivers, streams, ponds, and canals, should be considered for emergency use in the advance preparation.

Treatment of Water

The water available from emergency sources may require purification if it is to be used as a potable supply. Improvised treatment with disinfecting chemicals can be effectively applied under disaster conditions if adequate supplies of chemicals have been stockpiled in advance.

Where the character and extent of contamination indicates treatment in addition to simple disinfection, more elaborate mobile treatment units providing coagulation, sedimentation, filtration, and additional chemical treatment may be used. Any mobile units contemplated for disaster use should be assembled in advance.

Many health departments and civil defense agencies have portable chlorinators available for emergency use. In addition, various federal governmental agencies have stockpiled portable water filtration units at strategic sites. Mobile units may prove especially useful in supplying the larger water

allowances required for hospitals and mass-care centers.

As an essential item of preparedness, the water works personnel should be aware of all extra water treatment equipment and replacement parts in the area, and should be able to operate this equipment. A listing of chlorinators that are available at camps, hotels, swimming pools, sewage plants, milk plants, etc., should be maintained; however, the limitation imposed by the small capacity of such equipment should not be overlooked. Data on the operation and maintenance of this equipment should be on file, along with means of locating the persons in charge. A listing of the suppliers of water treatment chemicals and the location of warehouse supplies should be maintained for reference and use at time of disaster.

Hauled Water

Where it is not possible to distribute water to survivors through the piping system, it may be feasible to haul water in, even though damaged roads and debris may hamper vehicle operation. Hauling may be the only available means of distributing water to survivors while they are evacuating or while more permanent delivery facilities are being prepared. Sources of supply and means of hauling should be inventoried and considered in the advance planning. The hauling operation might well be made the responsibility of agencies other than the water utility, so that utility personnel can devote their time to putting the distribution system back into operation as rapidly as possible. As mentioned earlier, the amount of water that can be hauled into metropolitan areas may be insignificant compared to even the limited survival needs, and hauling will probably be only a last resort. The availability of sufficient motor fuel for large-scale hauling may be a further problem.

If a considerable quantity of water is to be hauled, it will be expedient to have tank trucks deliver water to designated locations where survivors may come to obtain it. The use of stationary storage tanks or other facilities to receive the hauled water and to deliver the water to consumers will reduce the over-all hauling time. Temporary storage tanks may be of plastic material stockpiled in advance.

Tank trucks can be requisitioned or volunteered commercial water-hauling trucks, milk trucks, street-flushing trucks, construction trucks, fire department trucks, tank trucks owned by farmers, etc. Small portable tanks may be mounted on commandeered flat-bed trucks. Fifty-gallon drums may be carried on semi-trailers, stake trucks, or vans and distributed at strategic points for the dispensing of water to consumers. Railroad tank cars are another means of hauling; however, damage of the tracks may necessitate transfer to other vehicles in order to reach the location of need. In other instances, rehauling from railroad sidings or spurs might be employed to serve hospitals and other areas in need.

Tanks must be properly cleaned and disinfected before use. Cleaning and disinfection procedures will depend upon the substances which the tanks have held previously. The utility personnel should be aware of the location of stations and facilities for cleaning and disinfecting tanks and containers. Advance consideration of this problem will result in efficiency at the time of emergency. It is advisable, as a minimum, to chlorinate the water in the tanks and containers to a free residual at points of distribution. Chlorination is simple and quickly accomplished, but in an emergency it may happen that even this measure must be dispensed with.

Bottled water may be obtained from bottled water distributors or by using the bottling or canning facilities of dairies, breweries, soft-drink companies, etc. The use of milk cartons or one-use containers is a good sanitary method for delivering drinking water. Cans, milk cans, and barrels may also be used. It must again be realized that such methods are suitable for a very limited population for periods of relatively short duration.

Water Stations

Emergency water distribution, pumping, and/or treatment stations may well have to be set up following a disaster to supply water for medical-care facilities, mass-feeding operations, essential industrial operations, commercial operations furnishing essential supplies or equipment, and for decontamination procedures. There must be advanced planning for the required equipment, supplies, and material. Treatment might have to be provided at the water station. The quality of the water should be properly maintained and the strictest conservation practiced at all water distribution points. If the availability of water is critical, it may be necessary to provide guards at the water stations to prevent individuals or mobs from overrunning the station.

Water may be served at these stations from fixed storage tanks, tank trucks, fire hydrants, or in small containers. It may also be served directly from a well or other source of supply. Water supply stations should be so located that they are convenient to the consumers. This is especially significant if there is fallout with a resulting radiation hazard and time outside the shelter must be minimized.

NOTIFICATION OF THE PUBLIC

Methods, procedures, and channels of communication must be developed in advance for obtaining and disseminating information to the public.

Survivors must be kept currently informed of the sources of water and the procedure to follow in order to utilize the supply. In the immediate post-attack period, the public must be advised of the water quality in the mains, the means of obtaining a satisfactory water, and the need, if any, to conserve or treat water. In time of natural disaster, it has been found that adequate notifi-

cation by waterworks officials has been surprisingly effective in preventing both water waste and panic. The statements issued should be concise, and presented so as to eliminate as much anxiety as possible. Information should be issued during all phases of the disaster period.

The public may be notified by radio, TV, placards, newspapers, telephones, handbills, soundtrucks, etc. A survey of all possible means of communication and a plan for coordinating these should be made in the advance planning. In addition, relations with the press and radio should be established so that there is a mutual understanding of the problems involved and agreement on methods to be followed.

Instructions distributed in advance of a disaster giving the consumers general information on the various means by which the essential water needs may be met should an emergency occur will reduce panic and otherwise enhance the success of the post-attack plan. Typical information to the consumer might include information on home storage of drinking and sanitary water, water waste prevention, what to do when the water service is interrupted, purification of contaminated or possibly contaminated water, and the need and procedure for obtaining information on the water supply following a disaster. Advance preparation could also include the making of placards and signs to direct the public to the water stations.

CHAPTER VI

GUIDE TO ADVANCE PREPARATION FOR RECOVERY OF WATER SUPPLY SYSTEM

The speed with which a water supply system recovers from nuclear attack will depend on the damage experienced, and also to a great extent on the degree of preparedness of the utility organization. The objective of this chapter is to provide information on the many considerations that will be helpful in the determination of the full consequences of nuclear war and its effect on water works, and to provide a means for each utility to develop civil defense capability to reduce these effects and minimize the consequence of an attack.

Among the measures which might be taken by way of advance preparation are those designed to minimize blast damage, which are collectively termed "hardening". Detailed consideration of hardening techniques was outside the scope of the present report; they include such items as use of structural design based on blast loadings and burial or shielding of critical portions of the waterworks system.

Although physical strengthening may largely decide whether or not a system located on the fringe of a nuclear explosion remains functional, advance preparation and planning for recovery and operation during disaster represents necessary insurance for prompt restoration. The utility's capacity to resume operation will be largely determined by the presence of waterworks personnel trained in effective methods of repair and by the availability of undamaged equipment material and facilities. The development of an operational plan for the post-attack period, together with personnel training, will make possible effective utilization of recovery capability. For municipal utilities, proper protection, supplies, and advance planning are vital factors in event of attack (13).

The following guide has been prepared to indicate the detailed administrative steps which might be included in an advance preparation program. The organizational procedure is presented first, and then the functional steps.

I. ORGANIZATION

A. Research and Development

1) Appoint a full-time disaster coordinator responsible for over-all direction of advance preparation including research and program development.

a) Provide a staff of full time employees for the disaster office of the larger utilities.

b) Establish clearly the areas of responsibility for all executive personnel.

2) Designate a disaster advisory committee of individuals with special knowledge and skills to assist in development of the disaster program.

a) Include in the advisory committee representatives of engineering, operation, laboratory, training, security, communications, records, shelter management, public relations.

B. Operational

1) Establish a disaster organization making use of all regular personnel as well as emergency auxiliary personnel.

a) Divide water supply system into self-sufficient zones for disaster operations, if this would be advantageous.

b) Designate personnel to disaster organization staff.

c) Designate alternates, with replacements at least three deep, for key positions.

d) Define channels of command and liaison.

2) Designate key stations for post-attack operations.

a) Designate command posts and alternates.

b) Designate control points and alternates.

c) Designate assembly areas and reporting centers.

II. OPERATIONS PLANNING

A. Preparedness Program

1) Disaster survival plan

a) Determine the procedures to be taken before alert, during alert, and following attack.

b) Provide for independent action of the various zone commands.

c) Time-phase plan by designating action to be taken after certain assumed periods.

d) Maintain operational plan in a state of readiness with a well publicized program, thoroughly trained personnel, and a continuing program of testing, evaluation, and revision.

2) Vulnerability Studies

a) Execution of study.

i) Items to be considered should include water system, personnel, power supply, communications, equipment, material, supplies, and emergency procedures.

ii) Base studies upon probable response to blast, thermal, and fallout effects of a nuclear weapon.

iii) Determine what overpressure ranges will produce various degrees of damage -- light, moderate, and severe.

iv) Estimate as thoroughly as possible the nature and extent of damage to be expected.

v) Prepare map showing location of residences and shelters of essential personnel and time of mobilization at various times of day and under various conditions.

b) Use of results.

i) Consider priority level various facilities may have in the over-all post-attack condition and determine the extent of "hardening" necessary to accomplish various degrees of protection.

ii) Use overpressure studies as a guide in comparing vulnerability of various typical units.

iii) Determine "hardening" measures for system facilities and personnel protection, availability, and training.

iv) Provide definite attainment goals time-phased for reasonable achievement dates.

v) Plan for continuity of operations through the application of vulnerability reduction measures.

vi) Provide for possible methods of repair and improvisation which may be used to restore operation affected as indicated by vulnerability studies.

vii) Use maps of residences and shelters to facilitate determination of vulnerability and availability of personnel at time of emergency.

3) Hardening and Facilities Protection

a) General considerations

i) Provide for high standards of construction and for optimum preventive maintenance on all regular, stand-by, and emergency facilities during pre-emergency period for maximum continued operation following disaster.

ii) Provide for duplication and separation of vital works.

b) Sources of supply

i) Provide sources at locations where pumping and distribution problems are minimized.

ii) Provide source pumping facilities with auxiliary power.

iii) Avoid dependence on one source and/or transmission line for entire system.

c) Distribution system

i) Maintain high standards of construction.

ii) Maintain active cross-connection control program.

iii) Minimize where possible dependence of distribution system on continuous operation of pumping facilities.

iv) Valve system so that repairs may be made without depriving service to extensive areas.

v) Install shutoff valves on leads to all fire hydrants.

vi) Equip service trucks with motor-driven equipment for operating valves.

vii) Test valves routinely (operationally and structurally).

viii) Make emergency or permanent interconnections between high- and low-level zones.

ix) Arrange system so that emergency pumps can readily supply needed fire and sanitary water from emergency water sources.

x) Equip repair crew trucks with disinfectants so that sterilization of repaired lines can be started immediately.

xi) Arrange distribution storage facilities so that they can be disconnected immediately to prevent water wastage and later be put into service as needed.

d) Treatment works

i) Provide for maximum flexibility in operation of treatment facilities when new works are constructed.

ii) Consider possible changes in operation of treatment works after a disaster.

a) Provide for ready conversion of all automated operations and controls to manual operation.

b) Consider special treatment against CBR contamination.

c) Consider disposal of radioactive waste material if radioactive supply is treated.

d) Consider increased dosages during emergencies of the normally used chemicals.

e) Provide for bypassing of treatment works.

iii) Maintain 30-day minimum chemical supply at plant.

e) Mobile treatment facilities

i) Maintain emergency mobile water treatment equipment including chlorination and filtration units with coagulation facilities.

ii) Provide mobile units for treatment of water containing radioactive materials.

iii) Maintain stockpiles of chemicals.

iv) Plan to use mobile equipment to treat water from system or other emergency sources to supply critical installations.

f) Pumping equipment

i) Provide dual power sources at pump stations.

ii) Provide on-site storage of fuel and auxiliary power units.

iii) Make available portable pumps with fuel-operated power units.

iv) Consider remote and/or automated controls.

v) Be able readily to convert automatic controls to manual operation.

vi) Provide more than one incoming and discharge water line for major pumping plants.

vii) Provide for shutdown of pumping plants so as to conserve water during extreme emergency.

4) Emergency Water Supply

a) General Considerations

i) Location of emergency water sources.

a) Determine means of locating essential water to be supplied to survivors during the early post-attack period.

b) Establish plans to obtain emergency water from utility system, auxiliary sources inside or outside the utility areas and from the hauling of water.

c) Provide for inventory of potential sources taking into account their location, maximum capacity, probable potability and safety, the need for treatment, reliability of continued operation during an emergency, means of connection, an estimate of the equipment or supplies likely to be needed in their use, and the means of locating the persons responsible for the supplies.

ii) Plans for supply of emergency water.

a) Establish plans for water stations for emergency water distribution, treatment, and pumping.

b) Provide for treatment of contaminated water, including the use of mobile treatment units.

c) Provide for responsibility for operation of emergency supply being delegated partially or totally to other agencies, if desirable.

d) Consider water allowances, rationing, priorities, and time-phasing of estimated water requirements.

b) Emergency water allowances.

i) Estimate water requirements for various times after hypothetical disaster.

ii) Determine minimum supplies, equipment, manpower, and organization arrangements needed to meet the water requirements.

a) Establish use categories such as potable, firefighting, decontamination, sanitary, industrial, and agricultural water.

b) Prepare water allowance scales by estimating water requirements for specific water uses.

c) Designate the emergency conditions used in determining water allowance scales, as for example - survival, early recovery, restoration, and reconstruction.

d) Establish appropriate allowances corresponding to criteria associated with each of the emergency conditions and water uses.

e) Prepare time-phasing assuming time intervals for establishment of water allowance scales.

c) Emergency water from utility system.

i) If necessary, provide water service directly from storage facilities, sources of supply, or from taps directly off of transmission pipelines.

ii) Use manifolds with a number of taps to increase delivery rate.

iii) Consider methods of rerouting water and the effect on the carrying capacity of the mains by valving off given sections.

iv) Provide for isolation of parts of system wherein water is carrying contamination, and warning the people in the service area.

d) Emergency water from auxiliary sources of supply.

i) Consider the following potential auxiliary sources.

a) Interconnections with adjacent water utilities.

b) Industrial or other private supplies with permanent interconnection or quick means of making connection.

c) Storage on private properties such as tanks, swimming pools, etc.

d) Surface waters such as lakes, rivers, small streams, ponds, quarry ponds, millponds, canals, etc.

ii) Consider likelihood that nearby works may be as badly damaged as those in utility system.

iii) Recognize that mains at fringes of system are usually of smaller size which will decrease amount of water available.

iv) Provide auxiliary pumping facilities, if needed.

v) Provide treatment, if needed.

e) Emergency hauled water.

i) Consider possibility of water delivery by tank trucks and railroad tank cars.

a) Tank trucks used can be requisitioned or volunteered commercial water hauling trucks, milk trucks, street flushing trucks, construction trucks, trucks owned by farmers, etc.

b) Small portable tanks such as 50-gallon drums may be carried on semi-trailers, stake trucks, or vans and distributed at strategic points for the consumers.

c) Consider use of stationary storage tanks to take water from the larger tank trucks which would take a long time to empty if delivering directly to individuals.

d) Railroad tank cars can be used with rehauling to distribution points.

e) Provide for disinfection of tanks and water.

f) Consider availability of sufficient fuel for large-scale hauling.

ii) Filling of tanks on trucks:

a) Consider use of short fire hoses in filling tank trucks from hydrants.

b) Consider use of a riser attachment with manifold for frequent and fast filling of a number of tanks at the same time.

iii) Use of bottled and canned water:

a) Obtain bottled or canned water using the facilities of bottled water plants, dairies, breweries, soft drink companies, canneries, etc.

b) Milk cartons, milk cans, and barrels may also be used to bring in hauled water.

f) Water stations.

i) Plan to provide emergency water distribution, treatment, and/or pumping stations for the service of essential water.

ii) Plan for the service of water from sources of supply, fixed storage tanks, tank trucks, fire hydrant taps, or in small containers.

iii) Determine equipment, supplies, and material required for this type of operation.

iv) Provide guards at the stations so as to prevent individuals or mobs overrunning and taking water to which they are not entitled.

5) Mutual Aid

a) General Principles

i) Provide for mutual aid and joint venture agreements for exchange or assignment of personnel, machinery, and stocks of essential materials and equipment during emergencies. (Cooperative, coordinated post-attack planning and joint prosecution of recovery operations).

ii) Include in considerations not only water utilities, but electric, gas, and telephone utilities; health, civil defense, fire and police departments, and other interested agencies.

iii) Provide in agreements for a definition of and assignment of responsibilities.

iv) Become familiar with relation of State disaster planning to area and local planning.

v) Consider the legal implications of mutual aid.

b) Area mutual aid and joint venture agreements

i) The area, organizations, and services to be included in these agreements must be clearly designated.

ii) Make area-wide inventory of materials, equipment, chemicals, and personnel available to cooperating agencies.

iii) Standardize emergency equipment and materials.

iv) Integrate emergency plan with suppliers of materials, components, and services.

v) Provide for comprehensive system of area-wide communication facilities and monitoring services.

vi) Include provision for area damage survey and assessment of the condition of the water system after a disaster.

vii) Provide for area-wide personnel training.

viii) Have area disaster plan operating staff keep utilities advised of current conditions.

ix) Inform all key parties to agreements where pertinent records are kept.

x) Keep other agencies currently informed of utility emergency personnel.

c) Local mutual aid agreements

i) Make local agreements with adjacent water utilities.

ii) Provide interconnections with adjacent water utilities.

iii) Plan and/or maintain interconnections with industrial or other private auxiliary supplies.

iv) Most of the considerations listed for area agreements also apply to local agreements.

6) Personnel

a) Utility personnel

i) Establish functional organization plan, assign personnel, and prepare them for disaster responsibilities.

ii) Plan to use regular waterworks personnel to maximum during a disaster as they provide the most reliable source of manpower for continuity of operations.

iii) Consider skills, number of personnel, and time required to perform each function.

iv) Utilize alternate and auxiliary personnel in various positions as a part of the preparation program.

v) Consider the capability of assigned personnel, including physical conditions, to carry out their assignment under emergency conditions.

vi) Allow for conflicting activities that may reduce availability and/or effective use of personnel in a disaster.

b) Auxiliary personnel

i) Provide manpower pool to supplement the normal working force during an emergency.

ii) Obtain auxiliary personnel from volunteers, or paid personnel with special experience.

iii) Obtain qualified auxiliary personnel from other water utilities, retired employees, former employees working on other jobs, sewage works employees, water or sewage works contractors and their employees, engineering consultants or specialists in fields relating to water supply, manufacturers of waterworks equipment, and commercial and industrial laboratory personnel, including those from hospital and university laboratories.

iv) Qualified auxiliary personnel may also be available from State and local health departments, U.S. Public Health Service, Army Corps of Engineers, National Guardsmen, and other military services.

v) Partially qualified auxiliary personnel may be obtained from utilities other than waterworks, related technical associations, or they may be plumbers, electricians, or other tradesmen.

c) Training

i) Train utility and reserve personnel on general civil defense subjects as well as specialized emergency waterworks operation.

ii) Provide personnel with details on disaster organization and operation, lines of authority, assignments, and action during a disaster.

Areas of training should include:

a) Assignments, location of mobilization centers, location of materials, when and where to report for duty, location and use of all equipment and supplies, and practice in the operation of emergency stand-by equipment.

b) Normal and improvised repair procedures.

c) Radiation exposure hazards and in operating in a radioactive environment.

d) Placing the system into operation after shutdown.

e) Taking over other jobs in utility as needed.

iii) Provide test exercises to determine adequacy of the civil defense emergency plan under simulated emergency conditions.

a) Repeat test exercises at regular intervals so as to perfect emergency procedures.

iv) Provide some training in conjunction with mutual aid program.

a) Familiarize operators with systems in adjoining communities.

b) Provide training in emergency anti-contamination measures, radiation monitoring, and decontamination in coordination with other civil defense agencies.

c) Execute test exercises in cooperation with local civil defense authorities.

7) Shelter

a) Provision of shelter structures

i) Consider personnel protection largely in terms of fallout shelters.

ii) Study characteristics of a desirable shelter.

iii) Make shelter survey including investigation of "natural" waterworks shelter areas such as pump stations, pipe galleries, and basements of filter, administration, or other buildings.

iv) Determine means of improving shelter protection in existing structures.

v) Consider provision of shelters in new structures.

vi) Consider sheltering of families of personnel.

vii) Determine number and location of shelters needed.

viii) Provide the necessary shelters in locations that all intended occupants can reach within a minimum period of time and near where the emergency work would have to be done.

b) Equipping of shelters

i) Equip shelters with essential survival items to provide reasonable living conditions for at least 14 days.

ii) In the shelter, consider space, ventilation, communications equipment, water, food, sanitary facilities, lighting, and any necessary special equipment.

iii) Connect shelters with utility communication system.

iv) Provide shelters with radiation monitoring equipment for checking outside radiation.

8) Security

a) Security protection needs

i) Determine degree of physical security protection needed against espionage and sabotage for the waterworks facilities.

ii) Determine degree of physical security needed for protection of personnel and records.

b) Provision of security procedures

i) Consider the provision of guard service, perimeter barriers, protective lighting, protective communication system capable of quickly alerting employees, screening of employees, employee identification and control system, visitor identification and control system, vehicle control system, and fire prevention and control.

ii) Consider emergency security procedures including the use of weapons, reporting of incidents, safeguarding classified material, critical area protection, and employee security responsibilities.

9) Communications

a) Provision and operation of emergency communications.

i) Provide radio and telephone facilities and integrate in emergency operation plan.

ii) Provide means for communication of mobile units with each other when base station not operating.

iii) Provide facilities for intercommunication or monitoring of nearby utilities.

iv) Train backup personnel to operate communications equipment.

b) Protection of equipment and facilities.

i) Provide standby power for operation of equipment at command and control points.

ii) Provide on-site storage of fuel and generators for auxiliary power at command and control points.

iii) Install in sites which are adequate as personnel shelters.

10) Laboratory

a) Provision of laboratories.

i) Provide laboratories in larger utilities where radiological, biological, and chemical determinations may be made.

ii) Determine availability of commercial and governmental laboratories.

iii) Designate alternate laboratories in case utility laboratory inactivated.

b) Laboratory operations.

i) Monitor raw and treated water in normal operation for radiological, chemical, and biological quality.

ii) Establish baselines on water quality levels beyond which predetermined procedures for identification, assessment of hazard, and taking of protective measures are initiated.

iii) Report laboratory findings promptly to waterworks management and public health officials.

iv) Develop equipment, procedures, and laboratory staff training so that a maximum number of samples can be analyzed quickly and efficiently.

v) Investigate rapid field screening tests.

c) Provision for continuing emergency operation.

i) Train available backup personnel in required laboratory determinations.

ii) Provide emergency water supply from protected source.

iii) Protect laboratory from blast damage.

iv) Tie laboratory into emergency communication system.

11) Records and Inventories

a) Maintenance of vital records.

i) Maintain up-to-date maps, engineering plans, operating procedures, and all essential records of the water system.

ii) Classify records that are being kept to determine which are vital and should be protected.

iii) Include in vital records all those records touching essential emergency administrative and operational functions, or protecting assets and legal rights.

iv) Record in easy-to-read forms and use standard symbols and terms whenever possible.

b) Availability of vital records.

i) Protect records by duplication, dispersion, vaults, or by providing for office personnel to take appropriate action to protect working records in the event of an alert.

ii) Make records readily available to key emergency personnel.

iii) Maintain duplicate copies at mobilization centers.

iv) Make duplicate copies available at other sites which are considered safe from a major disaster in the utility area.

v) Inform all parties to mutual aid agreements of these sites.

vi) Provide valve crews and service trucks with maps and current records showing location and condition of mains and valves.

c) Essential inventory records.

i) Inventory all emergency personnel, both utility and auxiliary, listing names, addresses, telephone numbers, availability of transportation, skills and disaster responsibilities.

ii) Inventory vehicles and equipment for hauling of emergency water.

iii) Inventory emergency stockpiled equipment, materials, chemicals, and supplies.

iv) List potential emergency sources taking into account their location, maximum capacity, probable potability and safety, need for treatment, reliability of continued operation during an emergency, and an estimate of equipment and supplies likely to be needed in their use. Describe means for making connection. List names, addresses, and telephone numbers of persons responsible for potential supplies. Show in records whether owner has signed agreement for public use of supply in emergency.

v) Inventory auxiliary chlorinators or other treatment equipment available in community with full data on type, capacity, use of equipment, and replacement parts that may be needed.

vi) Inventory other emergency equipment, materials, supplies and chemicals that are available in area.

vii) Inventory critical consumers and their water quantity and quality, and priority requirements.

12) Public Relations.

a) Designate a public information officer with alternates.

b) Develop means of disseminating information to the public following a disaster of water quality in mains, availability of a satisfactory water, and the need, if any, to conserve or treat water.

i) Consider notification of public by radio, TV, newspapers, telephones, handbills, sound trucks, etc.

ii) Provide for the issuance of statements frequently and clearly so as to minimize confusion.

iii) Prepare in advance news releases for emergency conditions that are likely to develop.

iv) Prepare placards and signs in advance to direct public to predesignated locations where water is made available.

v) Prepare list of essential industrial users who should be notified of change in water quality that would affect their product.

vi) Plan to keep water utility disaster staff informed of procedure for release of information to public.

c) Issue instructions to consumers in advance of emergency on disaster precautions and procedures, including information on home storage of drinking and sanitary water, water waste prevention, what to do when the water service is interrupted, purification of contamination or possibly contaminated water, and the need for obtaining information from authorities on the water supply following a disaster.

13) Radioactive Fallout Considerations

a) Protection.

i) Plan for protection from fallout of personnel, facilities equipment, and key operating areas.

ii) Provide adequately constructed, located and stocked shelters for personnel.

iii) Know protection factor for each shelter area - post in shelter area.

iv) Train personnel in protective procedures and precautions to be taken when working in the presence of radioactivity.

v) Provide personnel with protective clothing including coveralls, gloves, overshoes, parka, respirator masks and goggles.

vi) Consider fallout characteristics in construction of new buildings and in protection of existing buildings.

b) Measurement of Radioactivity.

i) Provide radiation monitoring equipment and train personnel in its use.

ii) Keep accumulated dose records for each employee using dosimeters.

iii) Provide monitoring equipment at each mobilization area or shelter.

c) Decontamination.

i) Provide methods for removing radioactive contamination from water supplies, such as settling, coagulation, filtration, ion exchange, and activated carbon.

ii) Provide methods for removing radioactive contamination from facilities and areas.

a) Remove by hosing, motorized sweepers, vacuum sweeping, push-brooms, use of detergent, solutions, abrasive treatment, dragtype scrapers, skip loaders, hand-shoveling, plowing, etc.

b) Let materials stand, thus allowing for natural decay.

c) Bury, dump or cover the contamination in a selected unused area.

iii) Consider the factors for determining whether a particular facility or area will be decontaminated and when, how, and

by whom:

a) The relative importance of the facility or area, the urgency in returning it to use, and the consequences if restoration is postponed for a period to permit additional decay.

b) The existing radiation intensity of the facility or area and the radiation level desired.

c) The travel time and work time which govern the amount of radiation outside the shelter the personnel will receive.

d) The number, availability, and condition of trained personnel and equipment to do the specific job.

e) The existing accumulated radiation dose of the personnel.

f) The feasible decontamination procedures.

B. Program for Operations During Pre-Attack Alert

1) Establish alert warning and reporting procedures.

a) Designate more than one operating category during alert period.

b) Provide signals to inform employees of each category.

c) Provide for transmission of information to utility control center on assessment of supplies, materials, and personnel in each mobilization area or shelter.

2) Establish procedure for reporting to disaster operation stations.

3) Establish procedure for placing vehicles, equipment, and critical materials under shelter.

4) Establish procedure for operation during alert pre-attack period, with particular attention to conserving water.

C. Post Attack Operations Program

1) Mobilizing available disaster staff.

a) Establish procedure for determining post-attack availability of waterworks personnel.

b) Establish procedure for use of available personnel.

c) Establish procedure for communication and use of personnel records.

d) Establish procedure for maintaining personnel information.

2) Assessment of damage and evaluation of surviving facilities.

a) Establish procedure for damage assessment and reporting.

i) Consider use of government reports, aerial monitoring and damage assessment, weather reports, information from CD Control Center, intercommunication with sheltered waterworks personnel, information from automatic controls and electronic sensing equipment, and waterworks and other CD personnel located where limited early assessment is possible.

ii) Plan probing operation to supplement D day information and improve assessment of damage. Information would be gained during a short period sufficient to permit decisions as to action priority and personnel, equipment, and material needs. The weaknesses found in the vulnerability studies would be the first place to look for damage in this phase.

b) Establish procedure for evaluating capability of surviving system.

c) Establish procedure for use of applicable records.

d) Establish procedure for recording and disseminating assessment and evaluation information to staff as needed.

3) Operation of surviving facilities.

a) Establish procedure for control of water loss and conservation of quality water.

i) Plan on isolation of damaged portions of distribution system.

ii) Fix procedure for isolating storage facilities.

b) Establish procedure for isolation of contaminated facilities.

c) Establish procedure for the activation of emergency source, treatment, storage, and distribution facilities.

d) Establish procedure for the reactivation of easily recoverable system facilities having high-priority need.

e) Establish procedures for improvised operating and repair methods.

4) Temporary Water Supply.

a) Establish criteria for determination of service areas that are to be supplied with water for survival by each of the various methods, such as piped community water, hauled water, evacuation of survivors to areas having water.

b) Determine means for making available essential water from utility system, and auxiliary supplies inside or outside utility area.

c) Establish procedure for using records pertaining to alternate supplies and critical water needs.

d) Establish procedure for the establishment and operation of water stations.

e) Establish procedure for the use of emergency water treatment where necessary.

f) Establish procedure for notification of public of location and quality of emergency water.

5) Recovery of system and restoration of operations.

a) Establish procedure for estimating manpower, equipment, and material needs to recover a sufficient system to provide at least 10 gallons/capita/day in early post-attack recovery period.

b) Establish procedure for putting into effect the emergency repair program.

c) Establish procedure for the reporting and recording of the current status of each of the waterworks facilities as recovery proceeds.

d) Establish necessary operational procedure for recovered facilities.

6) Operation in a radioactive environment.

a) Planning while in shelter.

i) Plan for personnel to remain in shelters until it has been determined that it is safe to leave.

ii) Provide for a prompt accurate flow of information upon which to base decisions following attack.

iii) Provide personnel with the means and knowledge of determining when shelter can be left and the length of time that one can safely work in a radioactive environment.

b) Considerations in beginning repairs or operations.

i) Consider making the most urgent repairs after necessary minimal decontamination, and to defer the less urgently needed repairs a sufficient time for radioactive decay to reduce hazard in area.

ii) If job would result in overexposure when assigned to one individual, assign additional workmen in such a manner that none are overexposed and lost to later recovery operations.

c) Operations outside shelter.

i) When decision is made to recover a contaminated installation, the first step is to establish a suitable staging area from which the recovery operation can be launched.

ii) Next survey vital area with regard to radiological contamination and physical condition, prepare site for recovery and test effectiveness of proposed reclamation measures.

iii) Prepare site by removing debris and obstructions, checking adequacy of water supply, drainage channels, etc.

iv) Clearly mark boundaries of vital areas, access routes, and staging areas to prevent entrance into hazardous areas or the bringing of significant amount of contamination into clean areas.

v) After operation is finished and radioactive area is left, remove contaminated clothing before returning to clean or relatively clean areas.

CITED REFERENCES

1. "The Effects of Nuclear Weapons, "U.S. Government Printing Office, Washington, D.C. (April, 1962).

2. "Exposure to Radiation in an Emergency", Report No. 29, National Committee on Radiation Protection & Measurements (January, 1962).

3. Birch, John S., "Variation in the Dose Factor for the First 24 Hours", Civil Defense Res. Proj. Issue No. 30, Univ. of California, Berkeley, California (August 31, 1960).

4. "Industrial Defense", The Provost Marshal General's School, U.S. Army, Fort Gordon, Georgia (June, 1962).

5. Owen, W. L., "Radiological Protective Construction", USNRDL-467. (January 8, 1962).

6. "Personal Preparedness in the Nuclear Age", IG-3-11 (Instructors Guide), OCDM (February, 1961).

7. "Radiological Decontamination", Office of Civil Defense, City of Los Angeles (April 1, 1960).

8. Lacy, W. S. and Kahn, B., "Survey Meters and Electroscopes for Monitoring Radioactivity in Water", Journal American Water Works Association, 55-65, 46 (January, 1954).

9. Hawkins, M. B., "Procedures for the Assessment and Control of the Shorter Term Hazards of Nuclear Warfare Fallout in Water Supply Systems", OCD Res. Project, Issue No. 34, Univ. of California, Berkeley, California (March 1, 1961).

10. "Permissible Emergency Levels of Radioactivity in Water and Food", TD-11-8, Federal Civil Defense Administration, (March, 1962).

11. "Ten for Survival" - Survive Nuclear Attack, OCDM booklet, (May, 1959).

12. "Minimum Potable Water Supply Requirements in Civil Defense Emergencies", (TB-11-16), OCDM, October 1958. (Reprinted in JAWWA, 51:964, August 1959).

13. Lacy, W. J. "Civil Defense and Munitipal Utilities", The Municipal South, vol. 9, No. 3, pp 19-25, March 1962.

APPENDIX A

Water Works Officials cooperating in study of Metropolitan water supplies in Civil Defense

ATLANTA, City of, Georgia

Paul Weir - General Manager, Water Department
C. W. Cline - Chief Engineer
R. J. Layton - Asst. Chief Engineer
Howard Bullard - Supt. of Maintenance & Operation
A. T. Storey - Supt. Hemphill Treatment Plant
Howard Peters - Supt. Chattahoochee Treatment Plant
J. L. Carr - Director of Laboratories

CHICAGO, City,of, Illinois

James W. Jardine - Commissioner, Dept. of Water and Sewers
Raymond D. Johnsos - Deputy Commissioner for Water
John F. Garrity - General Superintendent, Water Distribution Dir.
Harold A. Duffy - Civil Defense Coordinator

DENVER, City of, Colorado

Robert S. Millar - Secretary-Manager, Board of Water Commissioners.
Kenneth Mitchell - Administrative Assistant
R. B. McRae - Chief Engineer
Carl E. C. Carlson - Supt. of Operations
Jack Layne - Asst. Supt. of Operations
Kenneth Miller - Sanitary Engineer
Robert R. Ortell - Civil Defense Coordinator

DETROIT, City of, Michigan

Gerald J. Remus - General Manager, Board of Water Commissioners
Robert Blair - Supt. of Operations
Albert M. Shannon - Chief of Water & Sewage Treatment

LOS ANGELES, City of, California

Samuel B. Nelson - General Manager & Chief Engineer, Department of Water and Power
Max K. Socha - Chief Engineer of Waterworks & Asst. Manager Department of Water and Power
Ray L. Derby - Principal Sanitary Engineer, Department of Water and Power
Harry A. McFrye - Training Coordinator
Paul Pollock - Civil Defense Coordinator

NEW ORLEANS, City of, Louisiana

Edmund F. Hughes - General Superintendent, Sewerage and Water Board
Crawford J. Powell - Asst. General Superintendent
J. H. Coker - Utility Service Inspector
George Hopkins - Supt. of Water Purification

NEW YORK, City of, New York

Edward J. Clark - Chief Engineer, Department of Water Supply, Gas & Electricity
Abraham Groopman - Division Engineer
Harold Thackaberry - General Superintendent of Repairs
Benjamin C. Nesin - Director of Laboratories
Henry Leibman - Consultant, Department of Sanitation

PHILADELPHIA, City of, Pennsylvania

Samuel S. Baxter - Commissioner, Water Department
Gerald E. Arnold - General Superintendent, Water Department
Elwood L. Bean - Chief, Treatment Section

ST. LOUIS (Suburban Area), Missouri

H. O. Hartung - Executive Vice-President & Manager of Production, St. Louis County Water Company
J. L. Tuepker - Supt. of Purification
Oliver Norman - Supt. of Distribution
Dan F. Moroney - Supt. of Plants

SAN FRANCISCO, City of, California

James H. Turner - General Manager & Chief Engineer, Water Department
Harry W. Tracy - Manager, Water Purification Division and Civil Defense Coordinator

APPENDIX B

State Officials cooperating in study of Metropolitan Water supplies in Civil Defense

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Albert W. Happy, Jr., Director, Sect. Environmental Health Services, and W. A. Kramer, Chief, Public Water Supply, State Department of Public Health and Welfare, Jefferson City, Missouri.

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